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ORIGINAL ARTICLES.

I.—Notes on the Geological History of the Victoria Falls.[1]

By G. W. Lamplugh, F.R.S.

IT is difficult for anyone standing on the brink of the Chasm, after having seen the placid flow of the Zambesi above the Falls, to believe that the fissure into which the river is so suddenly precipitated has been formed gradually by the action of the river itself, and not by some great convulsion during which the very crust of the earth was rent. The narrowness of the abyss, the strange zigzags along which the tumultuous waters rush after their first great plunge, the mystery which has long surrounded the further course of the river after it swings away out of sight among its forbidding precipices, and the knowledge that the rocks across which it plunges are of volcanic origin, are all factors that have aided the illusion. Hence it is not surprising to find that the explanation given by David Livingstone half a century ago, that the majestic Zambesi has here been intercepted by a rent due to some earth movement in the solid rocks, has been adopted without question in all the later descriptions of this wonderful spectacle.

Meanwhile, however, geologists have been able to prove that in other parts of the world, canyons of even more impressive dimensions than this canyon of the Zambesi have been carved out by the erosive agency of water acting through very long periods of time; and this view has very recently been convincingly advanced by Mr. A. J. C. Molyneux, F.G.S., F.R.G.S., of Bulawayo, to explain the Victoria Falls and Canyon. In Mr. Molyneux's able paper ("The Physical History of the Victoria Falls," *Geographical Journal* for January, 1905), it is shown that the prevalent idea of a sudden rent in the

[1] A paper read before the British Association for the Advancement of Science, meeting in South Africa, at Johannesburg, August 30th, 1905. Reprinted from "The Official Guide to the Victoria Falls," compiled by F. W. Sykes, Conservator. (Bulawayo, 1905.)

earth's crust is inadequate to explain the phenomena observed around the Falls, while all the features are compatible with the view that the river has slowly sunk its channel into the hard rocks which have barred its passage seaward; and that the great waterfall has been developed as an incident in its long-continued work of erosion. A recent geological investigation of the country on both sides of the Zambesi between the Falls and the Deka River, about 70 miles eastward, has yielded much evidence confirmatory of Mr. Molyneux's conclusions, of which we can here give only the barest outlines.

It will be remembered that the Upper Zambesi flows, with a comparatively gentle course, over a portion of the elevated plateau of South-Central Africa, and that when it reaches the vicinity of the Falls its bed is still about 3,000 feet above sea-level. But at this point it breaks sharply away from its earlier habit, to begin a rapid descent across the mountainous eastern margin of the continent, and in doing so its capacity for erosive work is, of course, enormously increased. From the Falls onward until it reaches the coastal plain about 260 miles from the sea, the river has sunk its channel deeply through every obstacle, carving out narrow defiles like the Lupata Gorge, the Kebrabasa Gorge, the Kariba Gorge, and the canyon below the Falls, to which the name Batoka Gorge may be applied, wherever the rocks in its course are hard and resistant; and excavating a wider and less precipitous valley where it crosses the outcrop of strata that perish more readily.

The whole of the country for many miles on both sides of the Zambesi between the mouth of the Deka and Victoria Falls, and also for a considerable distance farther westward is occupied by hard basaltic rocks, the 'Batoka Basalts' of Molyneux, which have been poured out over the land as flows of liquid lava at some remote period of which the exact position in the geological time-scale has not yet been definitely ascertained. Scarcely was one of these lava-flows consolidated before it was overwhelmed by another, and still another, until the whole area surrounding this part of the course of the present Zambesi was covered to a depth of many hundreds, in places perhaps many thousands, of feet of volcanic material. The slowly-cooled central portions of these separate lava-flows have consolidated into the dense dark-blue rocks weathering with a brown crust that are so well seen in the precipices of the existing Falls, while their more quickly cooled slaggy upper portions, once porous with empty steam-cavities, have formed the deep red or purple 'amygdaloidal' bands that are rendered conspicuous to the eye, and very interesting to the mineralogist, by the varied minerals deposited by percolating waters. By this agency the cavities have been gradually filled up with the beautiful agates, green-coated chalcedony, quartz-crystals, and zeolites that may now be picked up so abundantly at the surface along the outcrop of these amygdaloidal rocks. And it may here be mentioned as of some interest to the archæologist that the chalcedonic pebbles have been frequently chipped to form rude cutting tools by some ancient race inhabiting the Zambesi valley, these relics of ancient man being especially numerous on the

patches of old river-gravel that are exposed around the low rocky bosses of the low ground in the vicinity of the northern bank of the river, in the angle between the Zambesi and its tributary, the Maramba.

The Batoka lavas in consolidating to their present state have developed a system of joints or shrinkage cracks which, together with rarer but more strongly marked lines of fracture or 'faulting,' have constituted planes of weakness that have materially facilitated the erosive work of the river, just as they would be found to facilitate the operations of artificial quarrying. Both 'master-joints' and 'faults' for the most part run approximately west and east, and are mainly accountable for the apparent vagaries in the course of the river, which in its innumerable windings through the Batoka Gorge tends constantly to take this direction, but crosses by rectangular or oblique traverses from one group of joints to another whenever the opportunity occurs. The Chasm into which the river plunges at the Falls is due to one of these lines of weakness in the rock, probably a fault-plane, where a vertical belt of comparatively soft vein-stuff, including a seam of crystalline calcite, breaks the continuity of the harder basalt. This vein may be examined by an adventurous climber in the little kloof at the eastern extremity of the Chasm; and its presence is indicated also at the inaccessible western extremity by the existence of a small cave, hollowed out by the surges from the Leaping Water.

At the remote period when the river first began to break across the eastern edge of the upland plains of basalt, the more powerful action of its troubled stream in this quarter, as compared with its tranquil course over the surface of the plains, must soon have brought about the development of rapids, cascades, and finally of a great waterfall separating the two portions according to their very different working capacity. The gradual recession of this waterfall by the undermining of its base and the breaking away of its edges, steadily progressing throughout the long period that these conditions have ruled in the Zambesi basin, are the main factors required for the interpretation of all the apparently complex phenomena associated with the present Victoria Falls and the Batoka Gorge; indeed, it is only thus that they become explicable. Among the many separate chains of evidence that strengthen this conclusion none is more striking than the different manner in which the tributary streams make their confluence with the main river above and below the Falls. Above the Falls the tributaries have had time to grade down their beds almost to the level of the Zambesi itself, so that (as, for example, in the Maramba confluence) we find a back-water from the main stream running for some distance into the mouth of its feeder, which here occupies a scarcely perceptible valley. Below the Falls, on the other hand, every tributary seems to emulate on a miniature scale the example of its mighty ruler and has sunk a deep gulch into the edge of the plateau roughly proportionate in length to the distance of its confluence below the Falls; and into this gulch it tumbles headlong from its older open valley on the

plateau, each little waterfall illustrating in its own small way many of the characteristics so magnificently displayed by its gigantic forerunner and originator. Another equally impressive line of evidence is afforded by the gradual falling away of the angle of slope in the Batoka Gorge itself as it is followed down from its present termination at the Falls. Here, as everyone may see, its walls, carved out as it were but yesterday, are approximately perpendicular, but even here they are already beginning to crumble down under the influence of the weather; at the distance of a few miles below the Falls, where they have been longer exposed to this influence, the average inclination falls to not more than 60°, and still farther eastward to 45° or less; and finally, in the lower parts of the Gorge, instead of the familiar wall-like lines of crags, we find that the river is bounded only by rugged hillsides whose average slope from crest to base is often not more than 30°.

The processes that have operated during the immeasurable past must continue also into the immeasurable future, so long as the Zambesi continues to thunder seaward over the edge of its upland basin. Imperceptible though the rate may be when measured by the short span of our human life, yet surely is the river gnawing its path backward into the heart of the continent; and the geologist, noting how already at the rapids above the Leaping Water the trench is deepening that draws down more and more of the flood at the expense of the shallower portions of the Falls, may look forward with confidence to a future when either here or along some still lower trench at present undeveloped the main trough of the river will become fixed. The present lip of the Falls will then be left dry to form another 'Knife-edge' around which the torrent will swirl in turmoil as it passes away from its new place of descent at some line of crags at present submerged under the placid waters of the upper river.

II.—The Mount Torlesse Annelid.

By F. A. Bather, M.A., D.Sc., F.G.S., British Museum (Natural History).

AMONG the geological specimens obtained by Mr. H. T. Ferrar, while the "Discovery" was visiting New Zealand, are seven rock-fragments containing tubular shells, and an eighth with some obscure markings. They are labelled as follows:—

No. 17.	Annelid tubes?	Mt. Torlesse.	H. T. F.	Dec. 8th, 1901.
No. 18.	,,	,,	,,	,,
No. 19.	,,	,,	,,	,,
No. 20.	Scaly markings.	,,	,,	,,
No. 21.	Annelid.	Mueller Glacier.	Presd. Capt. Hutton, F.R.S.	
No. 22.	Annelid tubes?	Kowai River.	,,	
No. 23.	,,	Wilberforce River.	,,	
No. 24.	,,	Gorge of the Ashley.	,,	

Specimen No. 20 may at once be dismissed with the remark that it is merely an irregular imprint, showing no structure; even the "scaly markings" of the label appear due to incipient cleavage of the

micaceous shale bearing the imprint. It may represent the "obscure plant remains" of Hector (1885, p. 339).[1]

The other specimens are all representatives of the fossil, or rather fossils, long known to the geologists of New Zealand as "the Mount Torlesse Annelid." This fossil is so abundant in certain dark-coloured slates and sandy shales, as to have procured for them and their associated sandstones the name of "the Mount Torlesse Annelid Beds" or "the Annelid Beds." These beds are usually regarded as the uppermost division of the Maitai Series, since they appear to be conformable with the underlying limestones, slates, and sandstones of that series. The fossils found in the Maitai Limestone, the basement bed of the series, as quoted by Mr. A. M'Kay (1879 and 1881) and by Captain F. W. Hutton (1885) are obviously Carboniferous, and, if correctly identified, should be regarded as Lower Carboniferous. Unfortunately the country in which the undoubted Annelid Beds occur is much disturbed, so that the stratigraphical evidence as to their relations is not free from uncertainty, and other beds have, it is now known, been confused with them in several cases (see, for example, Von Haast, 1885). Unfortunately also, the supposed Annelids are the sole fossils found in the beds. Thus the opinion published by Mr. M'Kay in 1881 still expresses the truth, namely, that "the placing of these Annelid beds in their correct position is unquestionably the most difficult problem that has yet to be dealt with in perfecting the classification of the older sedimentary rocks of New Zealand." "Much therefore," he continues, "depends upon the presence, absence, or correct identification of the annelid, which importance it must retain until other and more determinate forms are discovered" (op. cit., p. 90). Mr. M'Kay consequently proceeded to give a brief description, but up till now no figure has been published, and no comparison has been made with other fossils.

The material, as recognised by Mr. M'Kay, contains two quite distinct forms, which, however, are said to be found in precisely the same strata. One of these is straight (Nos. 17, 18, 19, 21, 24), the other curved (Nos. 22, 23). The former is the most widely distributed, being especially abundant and well preserved at Ashley Gorge, whence comes our specimen No. 24. The latter, according to M'Kay (1881, p. 91), is found only on the west coast of the South Island. The Kowai River, however, whence comes our No. 22, is on the east coast, disembogueing a little north of Port Lyttelton. With this exception, the localities quoted by Von Haast (1872 A–B), M'Kay (1881), Hector (1885 and 1892) may be supposed to refer to the straight form. It is pointed out by M'Kay that, although this fossil is called the annelid of Mount Torlesse, and although a long list of localities for it has been published, "it is nowhere spoken of as actually having been collected from Mount Torlesse." Hector, however (1885, p. 339), quotes it from "the south-eastern end of Mount Torlesse," while Mr. Ferrar found it to be "quite abundant near the summit of the hill."

[1] See end for List of Papers referred to.

THE STRAIGHT FORM. (Figs. 1–3.)

Mr. M'Kay (1881, p. 90) described this as "a tapering tubular calcareous[1] body, varying from one to three inches in length, the greater diameter of the larger specimens being not more than a quarter of an inch. In most cases when they occur between the bedding planes of the rock they are found flattened by the pressure of the overlying stratum, but when found vertical or highly inclined to the bedding planes they preserve their cylindrical form. In their fossil condition the walls of the tube are sufficiently thick to have resisted any ordinary amount of pressure exercised by the overlying beds, and therefore it may be doubted if they have always been as calcareous as they now are." Mr. M'Kay believes that the animals "were during life fixed to one place," and that the vertical "is their natural position."

To the preceding little can be added beyond more precise measurements. The greatest length of any of our specimens (No. 24, Fig. 1*a*) is 71 mm. (a little less than 3 inches), but this is obviously incomplete, being truncated at the smaller end by a slickensided joint-face, while the larger end has been broken off. At the smaller end, which is much flattened, the mean diameter is $(2{\cdot}3 + 1{\cdot}4) \div 2 = 1{\cdot}85$ mm. ($= \frac{7}{100}$ in.). At the larger end the mean diameter is $(2{\cdot}9 + 1{\cdot}9) \div 2 = 2{\cdot}4$ mm. The rate of tapering, therefore, is very slight, and the same is the case in other specimens. Since all the specimens are flattened in the plane of bedding, the lumen appears as little more than a dark line. A section of another individual in No. 24 gives the following measurements:—Greatest diameter, 4·7 mm. Least diameter, 1·3 mm. Greatest width of the compressed lumen, 2·7 mm. Thickness of tube-wall, on one side of lumen, ·3 mm.; on the opposite side, ·8 mm.; at one end, 1·3 mm. Probably this last measurement is exaggerated, and the lumen was really longer in this direction. Before compression, therefore, the tube at this level may have had a diameter of about 3·5 mm. with a wall ·8 mm. thick, and a lumen 2·7 wide, or just under four-fifths of the total diameter. These measurements should be checked from individuals preserved in a vertical position, such as unfortunately do not occur in the material under examination; but assuming their approximate correctness, it can scarcely be maintained that such a tube with its infilling of fine mud ought, however "calcareous," to have resisted the considerable pressure to which it has been submitted—a pressure which the rock-specimens themselves, as well as the published sections of the country, show to have been by no means "ordinary pressure exercised by the overlying beds." Consequently, there is no reason to suppose that the tube-wall was ever more horny than calcareous. As a matter of fact Mr. M'Kay's argument starts from an erroneous assumption: the substance of the fossil is not a carbonate or any salt of lime, but a chalcedonic form of

[1] Hector (1885, p. 339) also says "a calcareous tubular body." None of the specimens submitted by Mr. Ferrar are calcareous, but all, from all localities, are silicified throughout.

silica. In section the fossils are generally somewhat hour-glass or dumb-bell shaped, but this is an ordinary effect of compression, and there is no trace of lateral ridges such as characterise *Serpulites*. Unequal compression and a slight tendency to cleavage in the rock have produced inequalities of thickness, but the general impression produced is that the tubes were remarkably straight and not curved as in *Serpula*. The surface appears to have been smooth, but, if anything, irregularly and finely striate longitudinally rather than polished (Fig. 1*c*). There are no transverse annulations, wrinkles, or striæ, but specimen 19 shows a slight transverse swelling at one level (Fig. 2). The evidence at hand does not show whether the tube was closed or open at the smaller end. Probably it was not operculate at the broader end, or traces of the opercula would have been found.

Owing, perhaps, to its silicification, no microscopic structure can be detected in a thin transverse section of the tube (Fig. 3).

The specimens of rock, of which an average sample measures 100 × 62 × 18 mm., contain as a rule traces of more than one individual, but they are not very closely associated. Since there are in the rock no other solid bodies to which they can have been attached, it must be inferred that the tubes were free and isolated. While the evidence of the vertical specimens suggests that they were sedentary and embedded in the mud, the still greater number of specimens in the plane of bedding leads one to enquire how and when they left their vertical station.

The systematic position of this fossil is far from clear. There seems, indeed, no reason to doubt the unanimous ascription of it to the Polychæta tubicola, at least with as much reason as *Serpulites*, *Cornulites*, and similar forms; but the genus is not so obvious. Captain Hutton (1885) has suggested that certain annelids from the Upper Maitai beds of the Dun Mountain[1] are "perhaps *Cornulites*." The present specimens, however, assuming that they are of the same species, do not support that view, since they are devoid of annulations and taper much less rapidly.

From *Serpulites*, as defined by Mr. R. Etheridge, fil. (1880, p. 304), this species differs in the absence of the lateral ridges and in its straightness. The genus *Serpula*, as defined by Linnæus (Syst. Nat., 1758, p. 786), had "Testa univalvis, tubulosa, adhærens, sæpe isthmis integris passim intercepta." It is true that the first species mentioned by him, *Serpula seminulum*, "recedit a congeneribus quod libera sit nec adhæreat aliis corporibus," but this species cannot be taken as the genotype, and it seems justifiable to follow R. Etheridge, fil. (1880, p. 362) in regarding adherence as a necessary criterion of the genus. Another feature almost universally ascribed to *Serpula* is the irregular contortion or enrolment of the tube. On both these counts the Mt. Torlesse annelid is not a *Serpula*.

[1] Accounts of the Maitai beds of the Maitai River and Dun Mountain district near Nelson have been given by M'Kay (1878 and 1879), who, however, mentions only "Annelid tracks" and a shell like *Inoceramus*. But these beds were not then correlated with the Annelid slates and sandstones of Westland and Mount Torlesse, which were placed in an underlying Rimutaka series (see Hector, 1878).

The annelids secreting firm calcareous tubes do not, however, appear to furnish any other genus with which comparison would be profitable, and in general appearance this fossil most nearly resembles certain fossils rightly or wrongly assigned to *Serpula*. It is not the Mesozoic or Cainozoic species that it in any way resembles, but certain Palæozoic species, and of all these the resemblance appears closest to the Carboniferous fossil named *Dentalium indistinctum* by Fleming (1825) and *Serpula compressa* by J. de C. Sowerby (1829). That species, however, which certainly agrees with *Serpula* in its irregular curvature, and probably in its partial attachment, further differs from the Mount Torlesse fossil in the more rapid tapering and its relative tenuity of its tube-wall, notwithstanding the fact that the wall is described as "thick." It is thick relatively to the Palæozoic serpuloids, which therefore need not further be brought into comparison.

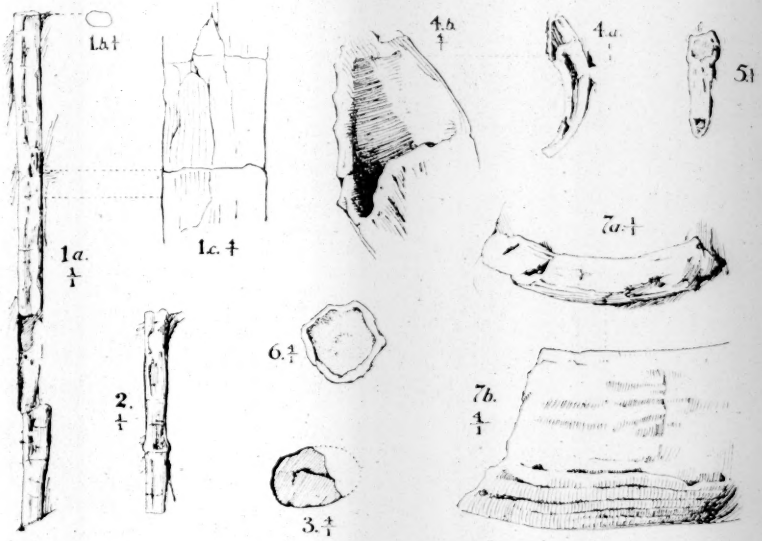
It is probable, and has thus far been assumed, that the tube of this fossil, though now chalcedony, was originally a firm calcareous secretion, a view confirmed by the composition of the other Mount Torlesse fossil. There is, however, just the possibility that the tube was an aggregate of sand-grains as in *Terebella*. The tubes of the various species of that genus differ from the present fossil in their irregular growth, while the calcareous sand-grains of which they are composed are certainly coarser than any which could possibly have entered into the composition of the New Zealand fossil. A much closer resemblance is presented by tubes from the Yakutat Slates of Alaska, recently described by Mr. E. O. Ulrich (1904, p. 132) as *Terebellina Palachei*, gen. et sp. nov.; indeed, some of his figures (pl. xi, figs. 2, 5) might almost serve as illustrations of our specimens. *Terebellina* is thus diagnosed:—"Long, subcylindrical, gently curved and rather thick-walled tubes, acuminate below; surface obscurely striated transversely. Tubes composed of cemented minute siliceous grains." These grains are "essentially the same as those of the arenaceous shale in which" the fossils "are found," but are "of more uniform and larger average size in the tubes than in the matrix." The length, the very gradual tapering, and the thickness of the wall ("about two-thirds of the diameter is taken up by the central hollow") are all points of resemblance to our fossil. It is further noteworthy that in Alaska as in New Zealand these peculiar worm-tubes serve to correlate exposures of slate of undetermined age in widely separated localities, and that the only other fossils are supposed fucoids and, in one locality, a peculiar concentrically ribbed Inoceramus-like shell. The Alaskan shell is named *Inoceramya* by Mr. Ulrich, to express his opinion that it is intermediate between *Posidonomya* and *Inoceramus*. On the evidence of all these fossils Mr. Ulrich assigns the Yakutat Slates to a Liassic age. But, although it would be important as well as curiously interesting to identify the Mt. Torlesse annelid with *Terebellina*, this course does not appear possible. Apart from the absence of any structure suggesting a similar constitution of the tube-wall,

there are differences in the absence of curvature and in the signs of a longitudinal rather than a transverse striation.

We come then to the conclusion—particularly unfortunate for the stratigrapher—that the straight annelid of Mt. Torlesse cannot be ranged with any established genus. Although further information is desirable, still it may be well to draw attention to the fossil by giving it a name:—

Torlessia, gen. nov.

A tubicolous Polychæt, of which the tube is unattached, straight, very slightly tapering, circular or elliptical in section, and with relatively stout, unridged, (originally) calcareous walls (*circa* one-tenth diameter); habitat, vertical in marine mud.



Torlessia Mackayi and Dentalium Huttoni.

1. *Torlessia Mackayi*, No. 24. *a*, natural size; *b*, section; *c*, portion of surface, to show striæ, × 4 diam.
2. *T. Mackayi*, No. 19. Natural size.
3. *T. Mackayi*, No. 19. Transverse section from another individual, × 4 diam.
4. *Dentalium Huttoni*, No. 22. *a*, a shell lying on its side, nat. size; *b*, larger aperture of same, showing ridges, × 4 diam.
5. *D. Huttoni*, No. 22. Another shell lying with the smaller curve uppermost, nat. size.
6. *D. Huttoni*, No. 22. Section of another shell as seen on the surface of the stone, probably not quite transverse, and partly crushed, × 4 diam.
7. *D. Huttoni*, No. 23. *a*, the largest individual on the stone, nat. size; *b*, a portion showing the ridges, × 4 diam.

Genotype, *Torlessia Mackayi*, n.sp.

Surface smooth or with faint longitudinal striation; description as above.

The association of Mr. Alexander M'Kay's name with this species requires no justification, as this is one of the rare cases in which the adoption of a personal name conveys a meaning which is not misleading.

Holotype: Specimen No. 24 of Mr. Ferrar's list (Fig. 1). Nos. 17, 18, 19, and 21 also belong to this species.

Horizon: Probably not below Upper Carboniferous and not above Trias (see Von Haast, 1887).

Localities: Ashley Gorge (holotype), Mueller Glacier, Mt. Torlesse, and many other places in New Zealand, especially Hutt and Selwyn counties (see Hector, 1885 and 1892).

THE CURVED FORM. (Figs. 4–7.)

This has not hitherto been described. It is represented by specimens 22 and 23, both collected by Captain Hutton. No. 22, from the Kowai River, is a water-worn pebble from which one quarter has been broken away. The substance of the pebble is a very hard dark-grey shale, weathered greenish. It is 19 mm. thick, 80 mm. long, and 63 mm. wide. On one of the flat surfaces, occupying an area about 52 mm. long × 50 mm. wide, are the remains of nineteen individuals, of which the most complete measures 19·3 mm. along the chord of the curve (Fig. 4). No. 23, from the Wilberforce River, is a fragment of hard black shale, iron-stained, slightly contorted, slickensided at one end, and with numerous cracks filled with silica. It is 14 mm. thick, 96 mm. long, and about 40 mm. wide. One flat surface is slightly water-worn and displays the remains of three individuals, of which the most complete measures 28·5 mm. along the chord of the curve (Fig. 7). In both specimens the substance of the fossils is silicified.

The above numbers suggest that these animals were more gregarious than *Torlessia Mackayi*.

In No. 22 the shells lie in all positions: most are in the plane of bedding, either on their sides, or with the concave curve up, or with it down; a few, of which only a transverse section is seen, appear to lie at an angle to the plane of bedding. Those which lie in the bedding-plane are compressed, and the side that happens to lie uppermost is usually pressed inwards so as to make the transverse section approach a semicircle or even a crescent. That this is an effect of pressure is further shown by the fact that the transverse sections mentioned above are more circular in outline.

The individual, 19·3 mm. long, on specimen 22, lies on its side, having the uppermost side crushed in, as above described, over the middle of its course, but partly broken away at the ends. The larger, convex curve has a radius of 12 mm. (a trifle over that of a shilling). The smaller, concave curve has a radius of about 7·6 mm., but is not so nearly a segment of a true circle. The outside diameter of the tube at a little distance from the larger end is about 4·3 mm., but since this end is broken, the diameter at the wider aperture cannot have been less than 5·3 mm.,

from which perhaps a little should be deducted for the flattening. At the smaller end the outside diameter is 1·6 mm. The thickness of the tube-wall at the larger end is not less than ·3 mm.; at the smaller end it was rather thinner. It is doubtful whether the transverse section was circular; it may have been slightly polygonal. The inner wall of the tube is smooth, but the outer wall was covered with about fourteen slight but distinct longitudinal ribs (Fig. 4*b*). These are almost or entirely worn away from the exposed surfaces, but are seen in section, and often on the impressed portions of the outer wall.

The three fragments preserved in specimen 23 all appear to have belonged to individuals rather larger than those in No. 22. They are much worn, and the tubes appear to have been filled with a greenish chalcedony rather than with shale. The ribs are shown in each of them, and very plainly in the largest, where three of them occupy a width of 1·2 mm. (Fig. 7*b*).

Of this form also, the systematic position is not free from doubt. Hitherto it has generally been regarded as the tube of an annelid, but to this there are certain objections. The shell, for instance, seems rather too stout and too regularly curved. Its general shape reminds one of *Cornulites*, to which Captain Hutton referred some tubular fossil (loc. cit. supra), but it is ribbed, not annulate. If an annelid it would be suggestive of a far later age than that to which stratigraphical evidence would assign it. Short, curved annelid tubes with longitudinal ribs do not seem to occur before the Lias, in which epoch there lived "*Serpula*" *quinquecristata*, Goldf., "*S.*" *tetragona*, J. de C. Sow., and *S. quadrilatera*. *Serpula heptagona*, Sow., from the Barton Beds of the Upper Eocene, is a similar form. But the most suggestive are the tubes from the Maestrichtian Chalk, now referred to Denis de Montfort's rather problematical genus *Pyrgopolon* (1808), e.g. *P. deforme* (Lam.) and *P. ciplyana*, Ryckholt. But none of these real or supposed annelid tubes has the same regularity of shape as appears to have been possessed by the present fossil. And if not an annelid, the conclusion is inevitable that it is the shell of a Scaphopod, probably of the genus *Dentalium* (sens. lat.). Since that genus, or some close ally thereof, has persisted from Devonian times to the present, this conclusion, while throwing no fresh light on the age of the rocks, is at least in harmony with other evidence. Several species of *Dentalium* or its subgenus *Entalis* have been recorded from Carboniferous rocks. Since the habitat of *Dentalium* is in marine mud, this conclusion further agrees with the evidence afforded by *Torlessia*. The fact that the stereom has been converted into silica renders inapplicable the argument from its arragonite or calcite constitution, and also prevents the investigation of its microscopic structure.

The tubes show no trace of slits at either end, so that it is legitimate to leave them in the genus *Dentalium*, even as now restricted (see Simroth, 1895, p. 458). Among the species of *Dentalium* (sens. lat.), both recent and fossil, the one to which the present form seems to bear most resemblance is *D. formosum*, Adams

and Reeve, from the China seas, since that tapers rather rapidly and has longitudinal ribs of about the same degree of coarseness. That species, however, has an apical fissure, is much straighter, and marked with transverse lines of growth. None of the Carboniferous species are so coarsely marked as the present one. It seems necessary, therefore, to establish :—

Dentalium Huttoni, n.sp.

A *Dentalium* (or allied genus) of which the shell tapers rapidly (from 25 to 7·5, length being taken as 100) and is strongly curved (radius of outer curve being *circa* 12 mm.), with about fourteen distinct longitudinal ribs.

Here too the name of the collector and donor of the specimens described, the lamented New Zealand geologist who himself alluded to them in his published writings, seems highly appropriate for the trivial appellation.[1]

Holotype: Specimen No. 22 of Mr. Ferrar's list (Fig. 5).

Horizon: Said to be the same as that of *Torlessia Mackayi*.

Localities: Kowai River (holotype), Wilberforce River (No. 23), and west coast of the South Island (*fide* M'Kay), all in New Zealand. Perhaps this is the same species as was found in the Maitai Series of the Taipo ranges by S. H. Cox (1877, p. 78) and referred by him to *Dentalium*; but it is not, of course, the same as any of the *Dentalium* from much later rocks recorded by M'Kay (1877, pp. 101, 110, 116, 117).

I am indebted to my colleagues Mr. Edgar Smith and Mr. G. C. Crick for kindly looking at these obscure fossils, and for raising no objection to the systematic position here proposed for them.

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[1] See p. 575.

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III.—On the probable Pelean Origin of the Felsitic Slates of Snowdon, and their Metamorphism.

By J. R. Dakyns, M.A., and Edward Greenly, F.G.S.

Part I: By J. R. Dakyns, M.A.

THERE are several kinds of acid volcanic rocks in Wales. In the neighbourhood of Snowdon there are at least five kinds, as follows:—

1. There are undoubted lavas, showing lines of viscous flow and sometimes vesicular, and weathering into cubical blocks. Such may be seen on Crib Goch and on Crib Yddysgl, on Cerrig Cochion, and elsewhere. These rocks are rarely cleaved.

2. There are rocks like the last as to fracture and mode of weathering, but which are neither viscous nor vesicular. They are probably masses of felsitic dust or mud. Such may be seen in Cwm Llan.

3. There are also massive felstones, rudely cleaved, such as form Moel Meirch and Clogwyn Llwyd.

4. There are the so-called ashes of various kinds, usually well-bedded and often highly cleaved.

5. Lastly, there are highly cleaved felsitic rocks, which show no lines of viscous flow, are generally unbedded, and which are in many places fragmentary. They are markedly different from the undoubted uncleaved lavas with which they are in some places associated; and though not readily to be distinguished from cleaved lavas they are so often obviously fragmentary that I cannot but consider them to be mainly of clastic origin.

With reference to these rocks Mr. Greenly wrote to me immediately after the meeting of the British Association at Southport

in 1903, saying that he thought the volcanic eruptions in the West Indies threw some light on their origin. Hence this paper, in which he sets forth his views on the subject. He proposed that we should write a joint paper, but I did not see my way to doing this, as I had no definite area mapped, and had not separated the cleaved felsitic rocks of doubtful character from the undoubted lavas and ashes.

I ought to say that the rocks like felsites in which I found fossils in 1900 occur in the calcareous felspathic ashy series near the base thereof; but are coloured pink on the Geological Survey map as part of the lower Snowdonian felstones. I have since then found fossils in another locality in an area so coloured, but not in a rock looking like a felsite. The fossils which I found in such a rock in 1900 were kindly named for me by Mr. E. T. Newton. They were *Strophomena* and *Orthis*; but the specimens were too poor for specific determination. The day after finding these fossils I discovered a small area of slaty rocks containing fossils, from 1,000 to 1,300 yards west of the summit of Moel Meirch, and entirely surrounded by the felstone of which that hill is composed. The relation of the fossiliferous rocks to the felstone is not clear. I suppose it to be an outlier, possibly faulted, of the calcareous ashes which, according to the Geological Survey map, overlie the felspar of Moel Meirch.

Though I have not finished mapping any well-defined area occupied by the cleaved felsitic rocks which form part of the lower Snowdonian felsites, I may point out some of the places where they occur and also places where they are of a fragmentary character. Cleaved felsites occur in Cwm Llan, extending from Lliwedd past Genallt and along the lower slopes east of Graig Wen. Their fragmentary character is well seen in Cwm Llan near the Gladstone monument. How like these rocks are in some places to the overlying ashes is shown by the fact, mentioned in the Geological Survey Memoir on North Wales (p. 151 of the second edition), that Mr. Selwyn had great difficulty in drawing a line of demarcation between them on the side of Cwm-y-llan near Yr Aran. It seems to me that the chief distinction in many places between the two sets of rock is that one is generally bedded and the other not. Though I have failed to find anything like stripe or lamination due to bedding among the cleaved felsites of Genallt, yet I have noticed a set of features, roughly parallel to the bedding of the ashes, running across the southern face of the hill. These are very conspicuous in a good light, and are suggestive of bedding; but they may be due to jointing. Cleaved felsites also extend from Bryn Gwynant, past Llyn Dû and Hafod Owen. Their fragmentary character is well marked in Coed Eryr and Coed yr Odyn. After crossing the line of the north-westerly fault at Perthlwyd, the rock forming the mountain between Llyn y Ddinas and Nant y Mor is felstone of the compact type, like that of Crib Goch, and is in places spherulitic. Cleaved felsites also occur in the outlier of felstone above Gelli Iago. The greater part of this outlier is compact uncleaved felstone with lines of viscous flow; but a small portion of

it is a cleaved rock of a quite different character, and in connection with this there is some bedded rock. I have not yet made out the relation of these two kinds of felsite to one another. There are probably some undetected faults, for, to mention only one place where such may occur, at the north-east end of the outlier shown on the map the underlying grits are dipping eastward so as to pass *over* the felstone or abut against it. The junction of the felstone here with the sedimentary rocks is more like the junction of an intrusive rock; but possibly this appearance may be due to faulting. There are other difficulties about this small outlier and also with the base of the felstone near Hafodydd-brithion, which I pass over, as they have nothing to do with the cleaved felsites which are the subject of Mr. Greenly's paper.

Part II: By Edward Greenly.[1]

Introduction.

Every geologist who has visited Snowdon must have observed that very large masses of highly cleaved, yet felsitic, rocks enter into the structure of the mountain, in addition to the unmistakable felsitic lavas and bedded calcareous ashes.

These rocks, which for conciseness may be called the 'Felsitic Slates,' are conspicuous along most of the ordinary approaches, except from Llanberis. The path from Pen-y-gwryd passes across them, and so does that from Beddgelert: they form the sharp ridge of Llechog, south of Cwm Clogwyn, and the great dark precipices of Lliwedd overlooking Llyn Llydaw are largely composed of them.

They are dense, hard, splintery rocks; intensely cleaved, and yet with the light weathering of a felsite, and also on fresh fractures their pale bluish-green matrix has, in spite of the strong cleavage, a decidedly felsitic aspect, while their cleavage laminæ are perceptibly translucent at the edges. Small squarish crystals of felspar, from 1·0 to 1·5 mm. long, are generally present and often abundant.

Most writers on Snowdon have, discreetly perhaps, said very little about them, for they are very unpromising-looking rocks. Sir A. C. Ramsay and Mr. Selwyn, however, having to survey the country, were obliged to deal with them in some way, and they have included them on the maps with the lower or principal felsitic lavas, with which they are coloured and lettered 'F.' Moreover, in the memoir (Geol. North Wales, 2nd ed., pp. 150–1) the intense cleavage is thus referred to: "On the ridge of Llechog, west of the peak of Snowdon, the felspathic porphyry is curiously cleaved, or at least very closely jointed; and so marked is this above Cwm-y-Clogwyn that it is difficult at first to believe that it is part of the very same slaggy-looking masses previously described. So completely is the appearance of the felstone of Llechog, and of the cliff below the peak of Snowdon, modified by this structure, that there

[1] All the field-work upon which this paper is founded is by Mr. Dakyns. I have only visited the ground a few times.—E. G.

is the utmost difficulty in fixing on a boundary-line between it and the overlying ash, both being felspathic and both cleaved and jointed. It is difficult to recognise the probability of intense cleavage being induced in a rock that has been melted, accustomed as we are to consider that cleavage of this nature is confined to stratified rocks. Less than two miles from this spot, on the sides of Cwm-y-llan, near Yr Aran, the same structure is remarkable, and it was not till after repeated visits and much study on the spot that Mr. Selwyn was enabled to draw the lines of demarcation between the ashes and the felspathic porphyry."

Mr. Harker, in describing the rhyolitic lavas, refers merely to an 'incipient' or 'imperfect' cleavage,[1] distinguishing it from the fine platy jointing and fluidal structure; and it is evident, therefore, that he is not referring to these rocks, in which the cleavage is correctly described by Ramsay as 'intense.'

Evidence of Clastic Origin.

In this Magazine for June, 1900, p. 268, in a paper on "First-fruits of a Geological Examination of Snowdon," Mr. Dakyns described these felsitic slates, distinguishing them from the other components of the lower felstones. He pointed out that in many places they can be seen to be fragmental (giving localities), and that these obviously fragmental rocks are part and parcel of the fine felsitic slates. He also drew attention to the absence of bedding, a character which we shall consider further on. We may add, perhaps, that were these rocks felsitic lavas, abundant traces should be found of the fluidal and also of the spheroidal structures that are so frequent in the true lavas. Cleavage would not have obliterated these throughout so large a mass of rock. In the paper quoted some microscopical evidence was also adduced, the most important part of which was that the felsitic slates contain a considerable quantity of calcite, whereas the felsitic lavas have in no case[2] yielded more than ·34 per cent. of lime.[3]

Re-examination of the same material has shown that some of the "small aggregates with igneous structure" are really felspars which have undergone a peculiar kind of alteration. But to this we shall revert in describing the metamorphism. Besides these, however, there are oval bodies consisting of felspars bound together by iron oxide and indeterminate brown matter, which probably represents a more basic glass, and these appear to be genuine lapilli. The fine matrix is far too much deformed and indeed reconstructed to retain any trace of its original texture, except under the sheltered 'lee' of some of the larger felspars, and in these parts smaller, subangular felspars can be seen which have the aspect of broken grains.

The conclusion arrived at by Mr. Dakyns in his paper of June, 1900, was that the rock was a felsite tuff or dust.

[1] "Bala Volcanic Series," pp. 16, 17.

[2] Harker, "Bala Volcanic Series," p. 13.

[3] The average of eight analyses of ancient and modern rhyolites given in Sir A. Geikie's "Text Book of Geology," 4th ed., 1903, p. 212, is ·698.

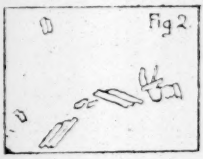
Fresh Evidence.

In April, 1900, Mr. Dakyns, while seeking for a good line of division between the calcareous ashy series and the underlying felsitic rocks at Hafod Llwyfog, near Llyn Gwynant, found, in a band of felsitic slaty rock, some Brachiopoda, the best preserved of which were *Strophomena* and *Orthis*, though Mr. E. T. Newton, F.R.S., who kindly examined these fossils, hesitated to name the species. Of the clastic origin of this rock there could therefore be no doubt.

To the unaided eye, or with a pocket lens, it has the same aspect as the other felsitic slates, though somewhat less fissile. If anything, it looks rather more like the felsitic lavas than they do.

Under the microscope, it is seen to be somewhat less altered, and the original character of even the finer parts can still be made out in places. It consists of the same small felspar crystals, set in a fine grey matrix, with streaks of calcite dust, which would account for the calcite before noted in the more altered varieties. There is also some chlorite. This matrix can be seen to be undoubtedly clastic, and consists of very small grains of felspar (quartz has not been identified), often of very irregular form. In other parts of the slide nothing but aggregate polarisation can be seen.

The most singular feature, perhaps, of the rock is the presence of a number of small flakes of biotite, with strong pleochroism, rich brown to nearly colourless. These are sometimes isolated, but more often in groups (Figs. 1 and 2), in which they and small felspars are



Figs. 1 and 2.—Groups of Biotite Crystals in Fossiliferous Felsitic Rock. Highly magnified (about ·23 mm.).

bound together by matter partly felsitic (giving aggregate polarisation) and partly still isotropic. The biotite flakes lie in all directions, and are evidently original constituents. Their arrangement suggests that these groups were originally lapilli, in which the biotites and felspars were cemented by a certain amount of glass. Most of the chlorite of the rock can be seen to be due to the alteration of biotite. Biotite in an unchanged condition has not, so far as we remember, been described from the Felsitic Series of Snowdon.

This rock, therefore, is a dust, mainly felspathic, but containing scattered lapilli of a somewhat more basic character.

Cleavage and Metamorphism.

Allusion has been made above, and was also in Mr. Dakyns' paper of 1900, to the alteration which these rocks have undergone in connection with the production of their cleavage; and in order to convey a clear idea of what they are now like it will be well to describe this, especially as some of the phenomena are in themselves of general interest.

The body of the rock is now an exceedingly fine mosaic, giving aggregate polarisation, but throughout this is a wonderful development of white mica, fine indeed, but with some flakes quite large enough to be recognised as individuals, and to give tints as high as the first blue in a slide in which the felspars give nothing but low greys. No part is free from this mica, but it is also aggregated into anastomosing seams, of which some are as much as ·5 mm. thick and wholly composed of mica. Indeed, between crossed nicols the whole slide lights up with its brilliant polarisation colours. There are many rocks in regions of admitted crystalline schists in which the development of mica is nothing like as great.

There is also a good deal of chlorite and some grains of quartz, and there are many lenticles of calcite, some of which reach 3 mm. in length by ·5 mm. in thickness.

Most conspicuous are the crystals of felspar, many of which have well-defined outlines, and often re-entering angles. Round these sweep the micas of the matrix, leaving the spaces under their 'lee' to which reference has been made.

The micas, however, do not bend completely round them, for in many cases they penetrate the crystal for some distance, its original outline being then obliterated. This generally happens at the ends of the augen, the micas which lie within the felspar crystal having the same direction as those of the matrix, the direction, that is, of the slaty cleavage. This is the same phenomenon as was described some years ago by one of us from the Harlech Grits.[1] In that case the cause could not be indicated with certainty. Here it is evidently an incident of the production of the cleavage.

In the microscopical notes incorporated in Mr. Dakyns' paper of 1900, mention was made of certain bodies with igneous structure, believed then to be fragments of igneous rocks. Most of them are lenticular augen composed of intergrowths of felspars, with beautiful polysynthetic twinning (Fig. 3). They lie in all directions within the lenticle, and interlock at their edges. In some cases chlorite and other products are also present, and it is possible that some of these bodies may really be lapilli. But re-examination has shown that a number of bodies, often with rectangular outlines, their longer axes lying sometimes transverse to the cleavage, and quite indistinguishable in ordinary light from the larger original felspars of the rock, reveal between crossed nicols the same internal structure as these complex felspar augen, being composed of a mosaic of clear, well-twinned felspars (Fig. 4). Some of the largest original

[1] Greenly, Trans. Edinburgh Geol. Soc., vol. vii (1897), p. 254.

felspars also show a tendency to break up at their edges into a mosaic. It is evident that the rectangularly bounded aggregates are really reconstructed felspars, and it is therefore probable that the lenticular aggregates are also felspars which have been deformed externally as well.

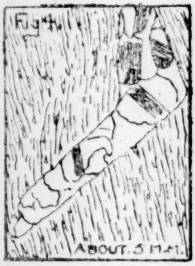


Fig. 3.—Felspar Lenticle in Felsitic Slate. About ·75 mm.
Fig. 4.—Reconstructed Felspar in Felsitic Slate. About ·5 mm.
In both figures the shaded bands are twin lamellæ.

This reconstruction of felspar is most interesting, particularly as it is evidently here a result of dynamic metamorphism, and as the resulting product shows no trace of mechanical crush or strain. Indeed, the extent to which mineral reconstruction has been carried is remarkable, when we reflect that no one would have called any rock of the series a 'crystalline schist'; that the results can be ascribed to no other agency than that which has impressed the slaty cleavage; and that this agency did not come into operation until after the Ordovician period.

Exceptional Nature and probable Origin of the Rocks.

From the evidence given in this paper it is clear that volcanic dust forms a large part, even if it does not form the whole, of the felsitic slates of Snowdon.

But the most remarkable feature of the deposit is the exceeding rarity of any signs of bedding. Intense though the cleavage is, it could not have obliterated this, nor indeed has it done so in the ashy series above or the sedimentary series below. And ages of weathering on the exposed faces of lofty cliffs could hardly have failed to reveal bedding if any existed; but in Llechog and other great crags nothing can be seen from top to bottom but the uniform vertical divisional planes which determine every feature. Yet such a mass of dust, if projected in the ordinary manner, and falling as a rain of ashes, could not fail to become stratified, even in the open air, much less on a sea bottom. The overlying ashy series is well stratified, and yet it is composed of much coarser material. Evidently, therefore, the felsitic slates, if a dust, must be due to some unusual kind of eruption.

Now, those who have read the fascinating report of Drs. Anderson and Flett on the West Indian Eruptions of 1902, will remember that absence of stratification is stated to be a marked characteristic of the deposits of St. Vincent, and is ascribed by them to the sudden and torrential or avalanche-like manner in which they were poured out.[1]

It is true that the phenomena which have given such a dramatic interest to these eruptions—the furious rush, the deadly blast, and the great black cloud—are essentially subaerial, and that the volcanic series of Snowdon is generally regarded as submarine. But as the conditions for the type of eruption, called by the authors of the report the Pelean, are determined in the throat of the volcano before emergence, there is nothing to prevent such eruptions taking place from submarine vents.

The felsitic slates, therefore, present in a striking manner one of the leading features of a Pelean deposit.

But there is another characteristic of a Pelean dust, equally important, and that is the high proportion of crystalline to glassy grains.

An ancient Pelean deposit ought, therefore, to be a largely crystalline deposit, and if not too much altered ought to retain some traces of this. The rocks under discussion, as we have shown, are for the most part much too highly altered for any but their larger original grains to be recognisable, but these grains are crystalline, and so far agree.

The fine matrix, in the highly altered rocks, might have been originally either crystalline or glassy, and proves nothing either way. But the fossiliferous specimen, we have seen, is much less altered; to it, therefore, we may appeal. Parts of it now yield aggregate polarisation, and these may, and very likely do, represent particles originally glassy, now devitrified, and there is even a little isotropic matter still surviving. But the greater part consists of broken felspars set in a dusty matrix in which smaller and smaller clastic, crystalline, particles can be detected, until we reach the limit of vision.

The dust is a crystalline dust, and, in addition to this, the groups of biotite crystals, cemented by what appears to have been glass, recall the lapilli with microliths and the crystals with glass adhering to them of the typical Pelean products of 1902.

Such evidence as we have, therefore, goes to confirm the view suggested in the first instance by their behaviour in the field, that in the felsitic slates of Snowdon we have a Pelean deposit of the Ordovician period.

Concluding Considerations.

One or two points call for remark. The particles, except the larger felspars, are decidedly smaller than those of the West Indian dust-clouds, even than what was collected at Barbadoes, some ninety

[1] Phil. Trans. R.S., 1903: Report on the Eruptions of the Soufriere, etc., pp. 448, 470.

miles away from the volcano. Possibly an acid magma may dissipate itself into finer débris than an intermediate one.

Then another point—and we confess to feeling somewhat staggered by this—is the enormous size of the mass. In the cliffs of Lliwedd alone several hundred feet of the deposit can be seen, and this may not be all, even if the rest of the horizon, estimated by Ramsay at 1,700 feet in all, be largely composed of lavas.

Another circumstance shows a curious coincidence. Drs. Anderson and Flett remark (Report, pp. 400, 505) that the Pelean type of eruption appears to be generally followed, when once the great black cloud has rolled away, by a 'rain of ashes' of the ordinary kind. Now in Snowdon itself it is certainly the case that the felsitic slates are succeeded by the bedded ashes of the upper part of the volcanic series.

As to the fossils, one could not, indeed, expect to find them in the heart of a thick deposit of Pelean dust. They were found in some thin bands which alternate with the upper ashy series near its base.

In one respect the hypothesis here put forward relieves the geology of Snowdon from a difficulty that has been felt, namely, the great extent of the felsitic lavas. For the horizon has been traced over a tract of country some fifteen miles long by nearly ten in width, and even then it ends off in escarpments. Certainly it cannot be less than 150 square miles.[1] It is difficult to believe that acid lavas, with their well-known viscosity, could be continuous over such a distance. Mr. Harker suggests[2] that under water they might retain fluidity much longer than in air. But the fluidal structure, so well marked and so common in them, shows that after all they could not have been much less viscous than other acid lavas. If, however, the 'Lower Felstone' horizon be composed to any great extent of pyroclastic matter, the individual lavas may be comparatively limited in extent, and emitted from several vents, now concealed beneath each other's productions.

Finally, it may be remarked that ancient Pelean deposits will easily escape detection unless they are thick, for a foot or two of homogeneous unstratified tuff occurring in a volcanic series would hardly attract attention. Yet the violent outbreaks from Pelée itself of May 8th and July 9th, 1902,[3] even that which destroyed St. Pierre, seem to have left only two or three feet of dust upon the surface.

However these things may be, and whether the view advocated in this paper proves to be correct or not, it is certain that the work of Drs. Anderson and Flett, and of the French and American geologists who have described these phenomena, will give a fresh stimulus to the study of volcanic action, and lend a new interest to many of our ancient volcanic deposits.

[1] Mr. Harker's estimate is much greater.
[2] "Bala Volcanic Series," p. 121, quoting Scrope and others.
[3] The mass ejected from the Soufriere was much greater.

IV.—The Recent Geological History of the Baltic.

Part IV: Climatic and other issues.

By Sir H. H. Howorth, F.R.S., F.G.S.

IN the first part of this series, p. 313, I referred to the recent invasion of the Eastern Baltic by the *Mya arenaria*, as first pointed out by Dr. Nathorst. Dr. Petersen has called my attention to an important paper by A. S. Jensen, which has apparently been overlooked by English conchologists, and I propose to condense his results, as they are very noteworthy from their geological lessons.

The shell has hitherto been treated as a typical Arctic shell. Thus Crosse and Debeaux write of its original home: "De l'océan Glacial arctique, qui paraît être sa véritable patrie, elle est descendue dans les mers du nord de l'Europe, jusques et y compris la Manche et une partie de nos côtes de l'Océan" (Journ. de Conchologie, ser. III, iii, 254, 1863). Gwyn Jeffreys, in describing the shell, says, "The occurrence of this circumpolar shell-fish so near the tropic of Cancer probably indicates *the most southern limit in space of the glacial epoch*" (Brit. Conch., iii, 65, 66).

Jensen has most clearly shown that these inferences are quite unjustifiable, and that the shell has, in fact, no pretension to be an Arctic shell at all. He has proved that in every case where it has been reported from Greenland, Iceland, Spitzbergen, Nova Zembla, the river Yenissei, and Bering's Strait, it has been mistaken for *Mya truncata*, var. *ovata*, and that its true habitat is limited to the North Temperate Zone. It extends southwards in the Atlantic as far as South-West France in Europe, and South Carolina in America, and in the Pacific to Japan and China between lat. 30° and 40° N. In the European area it is found in the British seas, Belgium, Holland, Germany, Denmark, and Southern Sweden. Sars reports it from the whole Norwegian coast, while Knipowitsch does so from the warm section of the White Sea (see Jensen, "Studier over nordiske Mollusker," part i, Mya. Videns. meddel. Naturhist. for. i Kjöbenhavn, p. 150, 1900).

This is not all. The curious fact remains that while its distribution is as here mentioned, and while it is virtually certain that it has migrated, not from the north, but from the south or west, it should have entered, not only the Eastern Baltic, but apparently the Scandinavian waters generally, so recently. It is still a most valuable article of food, yet it has never occurred in the Danish kitchen middens, where so many other edible molluscs occur. Nor has it been found in the raised beaches or the deposits in the Isefiord, etc., in the southern part of the Cattegat, now known as the *Tapes* beds, which synchronize with the kitchen middens, so that, as Petersen argued, it doubtless invaded the Baltic waters in the recent human period.

Brögger has discussed its distribution on the Norway coasts, and argued forcibly that there also it is a recent arrival, since it does not occur in the raised beaches properly so called. In the Christiania

fiord Professor Münster reported it from Smedholmen, near Brevik, in a bank which reaches down to only 66 feet above the sea-level, and Brögger urges that in this instance, as also in the case of Vallö, where it occurs at the sea-level, the shell has probably been thrown up by the waves, for it does not occur in the shell bank at Vallö nor in those at Tromö by Arendal. It has also occurred at Kadland, near Mandalselven, in conjunction with *Ostræa edulis*, *Cardium edule*, *Cyprina islandica*, *Tapes decussatus*, *Dosinia exoleta*, *Nassa reticulata*, *Polytropa lapillus*, *Gibbula cineraria*, *Turritella terebra*, etc. These shells must have lived in salt water and at a depth of some metres, while now the bed is found with only fresh water close by and above the sea-level. This, as Brögger says—and this instance is the sole one from Norway—shows that *Mya arenaria*, while living at the close of the *Tapes* time at the extreme south-western point of the land, had not arrived there at the close of the kitchen midden time (op. cit., p. 607).

A similar discovery of *Mya arenaria* was also made by Jensen in a raised sand beach at Nabsjert, in Vendsyssel, at a distance of 300 metres from the present coast and at a height of ·6 metre above the water. The shells measured 73 mm. in length (see Denm. geol., unter., 1st raekke, p. 279, n. 3). Brögger urges that this deposit dates from the same time as that at Kadland.

Brögger adds that further east, in the Langesunds and Christiania fiords, *Mya arenaria* only arrived in quite recent times (op. cit., p. 607). When Lyell wrote, in 1835, it had still a limited distribution in the Baltic, for he says, "This shell does not, I believe, extend so far north in the Gulf of Bothnia as Södertelje; I could not find it even at Calmar, and further south, at Sölvitzborg, it was rare and of very small size" (Phil. Trans., p. 10, 1835). Krajevnikof says all the specimens he had himself found were young.

Linnæus published the 10th edition of his "Systema Naturæ" in 1758, and there described the shell, p. 670, and gave it the name it still bears, and quotes as authority for it his own previous work, the "Wästgöten Reisa," p. 187, which was published in 1747, and where he names it *Concha subarenaceo marina* (under Concha he classes all bivalves). This seems to show that the shell was not known to him when he issued his earlier editions, and it was then probably limited to the western waters of the Baltic. As a proof of its rapid diffusion since, it may be well to give its present distribution in the Baltic, which is thus stated by Krajevnikof (Comptes Rendus Cong. Intern. Zool., Moscou, i, 151): Rugen, Stralsund, Greifswald, Stolper, the Bay of Dantzig, Calmarsund, Gotland, near Memel, Libawa, Windawa, near Riga, Dago, Oesel, Hapsal, Matzalwick, Réval, near Narva, and the Bothnian Gulf as far north as 62° 36′ N.

I have enlarged somewhat on the history of this shell in the north, because it has been made a kind of test of glacial conditions in England by C. Reid and others. Thus, in the Christiania Museum there are some specimens of it sent to Sars in 1866 by Crosskey and Robertson, and labelled "*Mya arenaria*, glacial clay, Kyles of Bute." On the ticket Sars has written "glacial" with a query,

and in his memoir, Chr. vid. Selsk. Förh., 1867, p. 58, he says that "the shells had reached him so labelled, but from what Mr. Crosskey told him he doubted if they were not postglacial" (Brögger, op. cit., p. 609). Brögger, in fact, suggests that, like other molluscs in the Christiania fiord, it is a vagabond from American waters (id., pp. 608–9). In his synopsis of the Post-Tertiary beds (id., p. 650), he makes *Mya arenaria* the index and typical shell of the last and most recent stage in the littoral shell deposits in Scandinavia.

Secondly, in a passage in paper II of this series (see p. 352) I ventured to question whether in every case the raised shell-beds marked the permanent level of the water or only its transient passage after some impulse. This latter conclusion is doubtless sound in some cases, but it cannot apply to all, for in many of them the shells are clearly *in sitû*. Thus Lyell expressly says that "in the gravel-pits at Solna, near Stockholm, the shells consist principally of *Cardium edule* and *Tellina balthica*, a great number of which have both their valves united." Again, speaking of *Mytilus edulis* at the same place, he says, "There has been a great accumulation of this shell in the stratum, but it is almost entirely decomposed, and is only recognized by the violet colour which it has imparted to the whole mass" (Phil. Trans., 1835, p. 5). The molluscs in this bed are therefore clearly *in sitû*, and not remanié. It is 30 feet above the level of the Baltic.

In another bed at Bränkyrka, 70 feet above the sea-level, the shells are also clearly *in sitû*, being described as embedded in a peaty soil containing fragments of wood, which peat, Lyell suggests, has been derived from seaweed, large accumulations of which he saw heaped up in a bay of the Baltic near Sölvitzborg, intermixed with similar species of shells (id., p. 6). Again, at the Bläbacken and near the Quarnbacken, Lyell describes beds of marl three feet thick, at a height of about 100 feet above the sea, as being remarkable for the violet colour imparted to them by the decayed *Mytilus* shells, and, he adds, "with the exception of the *Mytilus* the shells are generally very entire" (id., p. 7). Again, in a bed from 30 to 40 feet above the sea-level at Ulfva, on the banks of the Fyrisâ, he found a blue clay containing abundant specimens of *Tellina balthica* entire, with both its valves and the epidermis. *Mytilus edulis*, often much flattened and occasionally covered with the small white flustra so commonly attached to it in the Baltic, also occurred there (id., p. 14). From the opposite coast of Finland he cites the discovery of a section with marl of a violet colour at the height of 60 feet above sea-level at Nädendal, near Åbo, as also composed of the decomposition of *Mytilus edulis*, and as also containing perfect specimens of *Tellina balthica*, *Litorina litorea*, *L. rudis*, and *Paludina ulvæ* (id., pp. 22 and 23).

In all these cases there can be no question of remanié or rearranged beds, but of beds in which the molluscs actually lived, and which have been raised to the height of many feet above the sea-level since the shell-fish were living; and they testify unmistakably to a corresponding rise of the land, and not to a mere

passing tidal wave depositing its burden. This evidence is, however, at first sight difficult to equate with the experimental evidence based on investigations specially directed to test whether the land has been and is now rising gradually from the sea. On this latter issue a very large and divergent testimony is available, for the polemic has now lasted for nearly two centuries, since Celsius wrote his well-known memoir in the Transactions of the Stockholm Academy.

There can be no doubt that, as in the case of all inland seas into which a large number of rivers laden with sediment are perpetually pouring, the accretion of sedimentary matters in the Baltic, especially its northern part, is causing not only a shallowing of its waters, but a great advance of the shore-line, which has gained enormously in consequence. Thus, as Lyell urges, it was pointed out by the opponents of Celsius that by the process of delta-making there had been a gain of half a mile in 45 years at Piteo, and of a mile in 28 years at Luleo, both in the Gulf of Bothnia ("Principles," 12th ed., vol. ii. p. 182). This cause, as in so many places in England, has induced the shallowing of harbours and the presence of shells far from the sea in the black clays forming a kind of delta deposit in so many places, etc., etc., and no doubt many of the alleged instances quoted to prove an actual rise of the land are attributable to this quite different cause. Others are due to test marks having been made on stranded boulders which have been actually moved into shallower water, and thus giving misleading evidence.

Another misleading element is the extreme variation in the normal level of the Baltic water. Although there is no actual tide in that sea, there are other notable causes of variation in its level. It has been ascertained that the great differences sometimes occurring in barometrical pressure cause a corresponding differential change of several feet in different parts of the sea. A similar effect is induced by the variation in the amount of fresh, and therefore light, water and of salt water, which causes a change between the Summer and Winter level of the sea in different parts, and, in fact, its level in the upper parts of the Bothnian Gulf has been experimentally shown by Mr. Wolfstedt to vary as much as 18 feet from that of its southern parts, and it no doubt again varies greatly according to whether the rivers and upper parts of the Bothnian Gulf are frozen or free.

This variation qualifies immensely the value of various experiments which have been made at different times by putting marks on exposed rocks, etc., at the sea-level and then examining them some years afterwards to see what changes have occurred. There is a double ambiguity in the process, one dependent on the controlling conditions of level when the mark was made, and the other on the similar conditions when it was afterwards examined. Hence the different and inconsistent results which have been drawn from this kind of evidence, and I am bound to say that Lord Selkirk's careful examination of the problem on the spot

and his re-measurement of the different marks justified the conclusion he came to, namely, that "*they prove nothing.* The daily and weekly alterations in the level of the water caused by changes of the wind, and sometimes, I believe, by winds not felt at the spot where the change of level takes place, are so very considerable that anything that may have taken place in 30 years is almost imperceptible in comparison." After quoting some special cases to show the difficulty he says: "From this I infer that until the average level is more clearly ascertained, no inference can be drawn from these marks." After again referring to the possibility of the stones themselves having been raised or moved by shore ice, he quotes a Swedish report by Mr. G. Widell on the marks at Marstrand, who had come to the same conclusion as himself as to the uncertainty of any inferences to be drawn at present from these marks. Mr. Widell was the Rector of the Academy at Marstrand (Q.J.G.S., xxiii, 191–196).

If we turn from the experimental tests to evidence of another kind, there is a very extraordinary concurrence of testimony in favour of the conclusion that the older writers like Celsius, Von Buch, etc., who believed the changes in the Baltic to be still in progress and to have been progressive from early times until now, were mistaken.

Lyell, whose frank acknowledgment of the facts on the other side is always so notable, quotes the cases of the castles at Calmar, built in 1030, and of Abo in Finland, whose position near the sea makes it impossible to believe that there can have been much change of level since they were built. He refers again to the records about certain oak-trees at the fishing park of Fiskertorp on the Malar Sea, and declared by the keeper of the Royal forests to be 400 years old, and yet growing but ten feet above the level of the present tide (Phil. Trans., 1835, p. 13).

He also quotes a more critical test case, cited by the older Swedish writers: "On the shores of the Gulf of Finland were formerly some pines and oaks growing close to the water's edge; these were cut down, and by counting the concentric rings of annual growth, as seen in a transverse section of the trunk, it was demonstrated that some of them had stood there for nearly 400 years. Now," says Lyell, "according to the Celsian hypothesis the sea had sunk about 15 feet during that period, in which case the germination and early growth of these trees must have been for many seasons below the level of the water" (Lyell's "Principles," 12th ed., ii, 183). The argument, he adds, founded on the position of the trees, is, as Professors Lovén and Erdmann have lately remarked, unanswerable so far as it relates to a part at least of the Finnish coast (id.).

I may quote another piece of similar evidence which seems to me also very conclusive. On November 12th, 1903, Mr. W. Wermersten read a paper before the Students' Association at Upsala on an old deposit of the Stone Age in the south of the Island of Gotland. Parts of human skeletons as well as bones of dog, pig, and seal were

found not more than 1–1·5 metres above the present sea-level, a proof that the elevation of the Isle of Gotland was all but finished at the end of the Stone Age (Bull. Geol. Inst. Upsala, vi, 280). This seems to me to present very important evidence that the upheaval of that island, like that of the mainland, was in the main, at least, before the Stone Age.

The same testimony is borne by the island of Biorkö in the Malar Sea, which contains a vast cemetery and other remains of the pagan Viking time, and can only have changed its level very slightly since the tenth century, which may be put therefore by the side of similar instances in the Cattegat. Standing in the midst of the fiord is the small island of Anholt. On the littoral beds, just above the water-line, are found remains of the Stone men, showing that the level of the island has not perceptibly changed since they were living. Again, historical documents show that the island of Saltholm, which is only slightly raised above the sea-level, has remained practically at the same level since the year 1280.

This kind of evidence, which is widespread, and might be much enlarged (and notably by the records of the various maritime towns in the Baltic lands, showing how stationary they have been for a long time), is very important when put beside the unmistakable evidence of the raised shell-beds, in regard to the level of these lands having been greatly raised in Middle and Northern Sweden since the invasion of the *Litorina* fauna; and it goes to show that the views of Von Buch and others in favour of uniformity in regard to this problem are not sustainable, but, on the contrary, that this undoubted movement of upheaval was largely limited to the times preceding or contemporary with the Stone Age, or at least to primitive times.

This invites the further question as to whether it was a gradual upheaval or, as I firmly believe, a spasmodic and intermittent one. The latter conclusion seems to follow from the fact that the shells do not occur in regularly sloping and continuous beaches, as we should expect in the case of an uprising coast of a sea where there is virtually no tide, but, as at Södertelje, at various heights in the strata separated by barren intervals (Lyell, op. cit., p. 10). The fact of the shells occurring in detached beds, and not being regularly distributed throughout the whole depth down to the sea-level, seems clear evidence that their deposition was intermittent and not gradual.

Another fact difficult to account for on any other theory is, that the shells in the shell-beds, instead of gradually increasing in size and gradually losing their distorted forms as we get higher in the beds, until we reach a layer where they are of the normal size and appearance of those in the outer sea, are described as all dwarfish in size, just as they are found in the brackish water of the neighbouring Gulf of Bothnia, and the whole assemblage of shells such as characterizes the Baltic. Recent writers, although they have noticed a certain dwarfing of the living forms when compared with those in the raised beds, yet declare the latter to be much dwarfed and distorted, and I know of no specimens found in the raised beaches of a normal size.

I have ventured to draw another inference in regard to the abruptness of the upheaval of the shell-beds from the abruptness of the gap and want of conformity between the *Ancylus* and the *Litorina* beds. The fact of this unconformity is emphasized by the Swedish geologists. Thus Nathorst says that "De Geer, in his more recent papers, has pointed out that in many places in the peninsula of Upland, especially in the neighbourhood of Upsala and Stockholm, there is a discordance between the *Litorina* clay and the lighter-coloured Baltic clay of Munthe on the one hand and the *Ancylus* clay on the other. According to Hogbohm and Munthe, again, the former clay in the district of Upsala is in certain places separated from the *Ancylus* clay by a layer of sand or a clay-like sand formation of a depth ranging up to several metres; there can therefore be little doubt that there is a breach of continuity between the beds, thus representing an abrupt change and involving more or less troubled conditions" (Nathorst, "Sueriges Geologi," p. 268).

Numerous additional facts, therefore, are available to support the not generally accepted conclusion that the rise of the Baltic lands not only took place in the main and perhaps entirely in primitive times, but that the same rise was intermittent and not gradual, and was rapid and sudden and not continuous and slow.

Let us now turn again to the sinking in the southern Baltic area which broke down the Baltic breach. This has been thought by some of the northern geologists to have been a very general phenomenon, in which a large part of Scandinavia had a part. As attested by the evidence, however, it was very local, and involved only the narrow seas separating Skäne from Mecklenburg and the mainland generally.

To the evidence already cited of the fact itself I should like to add some more recent testimony. The 2nd part of the 3rd series of the Danish Geological Survey publications is a synopsis of recent progress in geology in Denmark by Ussing, who mentions instances of submerged peat bogs recently found at Graadyp, north-west of Fanö; in the dock works at Esbjerg, and Aarhus, and at various places near Copenhagen and Bornholm. A famous example was that disclosed in 1899 during the drainage works at Copenhagen and at a place where the water was 40 feet deep. Ussing says expressly that the position of this submerged peat bog in relation to the depth of the Sound shows that it may have been once a part of the land communication between Copenhagen and Malmö (op. cit., p. 313). As he says, "Som sammenlignet med Öresundets Dybdeforhold antyder, at der maa have vaeret landfast Forbindelse mellem Kjobenhavn og Malmö."

The deposit at Esbjerg, of which a very good profile is given by Hartz, shows a bed of turf two inches thick covered by 1·5 of sand, etc., including a layer of sand with shells. The bed of turf lay 4·5 metres under high-water mark.

In addition to peat mosses, submerged trunks of trees have also occurred in similar localities; thus in indamming land at Vigero, 3,000 feet outside the south coast of the Odense fiord, stumps of

trees were found rooted in the so-called moraine clay, including those of a fair-sized oak wood. The level on which the trees grew is now submerged to the extent of two feet. In the old harbour of Copenhagen were also found remains of an old wood 20 feet below the surface (Ussing, op. cit., p. 313).

Another striking proof of the same fact is the submerged and sinuous channel in the Odense fiord, or the Sound as we call it. The course of this channel has been mapped out on one of the plans in a volume of the Transactions of the Copenhagen Geological Survey. From this it is clear that this furrow forms a continuation of the Odense river, and its depth in certain places is more than 11·3 metres, or 36 feet, and it must, as Ussing says, be deemed the former bed of that river. A proof of this is forthcoming in the fact that the deepest tracks of the furrow are not where the fiord is narrowest, and where, therefore, the scour is the greatest. Not only so, but the channel itself, instead of having been the result of scouring by a race or tide, has been and is being filled up. Its bottom is covered with more than five metres thick of *Cardium* mud, while outside the channel itself the deposit is not more than one metre, which proves that here we have to do with an old furrow or channel which is being choked up and not cleared out. Similar conditions are found in the smaller and subsidiary channels and in those which run into the principal branch, forming, there can be little doubt, the drainage of the area of the Sound when all or the greater part of that area was dry land.

Again, I have ventured to argue in a previous paper that the great collapse or breach, by which the Baltic was converted from a fresh-water lake to a brackish sea, was, like the corresponding upheaval further north, rapid or sudden, and took place while man occupied the country. This enables us approximately to date it.

According to the latest opinion of Dr. O. Montelius, the Swedish archæologist who has devoted the most time to the study of primitive man in Scandinavia, the Bronze Age in Sweden began about 1700–2000 years B.C. This is an approximation deduced from a comparison of the shapes and ornaments on the bronze objects in the northern lands with those of the Mediterranean, whose probable date we can fairly fix, and it takes us back 3600–3900 years from the present time for the commencement of the Bronze Age in Scandinavia.

The preceding Neolithic age, judging from the enormous number of monuments and remains it has left in the North, must have been very prolonged. As many as 36,000 finds of the post-kitchen-midden Stone Age had been reported from Sweden alone up to the year 1874. The Neolithic age in Denmark has been divided into two sections, one comprising the remains of the kitchen midden times, i.e. of the older race of new Stone men who did not use polished tools and had no domestic animals except the dog, and a second era during which men used polished stone axes and more shapely and elaborate chipped ones, and kept domesticated animals.

According to the evidence, as we have seen, the breach in the Baltic bridge took place after the kitchen midden time and during the succeeding period of the Neolithic age. That is a *terminus a quo* from which we may roughly calculate the time that has elapsed. Von Baer, who was the first, I believe, to make such a calculation, put the date of the breach at 5,000 years ago. He based his calculation, however, on the uncertain element of the rate at which the Baltic lands were supposed to be now rising.

Dr. Brögger, in his book on the Mollusca of the Christiania Fiord, bases his calculation on the archæological evidence, and puts it at 8,000 years ago.

If we take the mean of these two calculations, say 6,500 years, we shall perhaps roughly approximate to a tentative date since which salt water has been flowing into the Baltic basin, and introducing partially marine conditions there, while the fresh water has been flowing out in a large stream into the Cattegat and destroying the oysters and associated shells there, initiating the *Litorina* sea on the one side and pushing back the *Tapes* sea on the other. This double action of the catastrophe seems plain from the evidence, and I therefore cannot agree with De Geer and Brögger when they equate the *Tapes* and Oyster period in the southern Cattegat with the *Litorina* stage of the Baltic, instead of with the *Ancylus* stage. The *Litorina* time was, in fact, the inception of the present condition of things in the Baltic, as the contemporaneous *withdrawal* of the *Tapes* fauna initiated the present condition of things in the Cattegat.

The next question is to ascertain what climatic changes we can predicate in Scandinavia during the interval bounded by the beginnings of the *Litorina* time and the close of the *Tapes* time on the one hand and the present day on the other. First let us look at the question from an *a priori* view.

Ekholm, in a paper in Ymer, Heft iv, p. 377 ff., translated in the 27th volume of the Quart. Journ. of the Meteorological Society, No. 117, January, 1901, has argued that about 8,000 years ago the Summer temperature in Mid Sweden would be enhanced to an extent of 2 degrees Centigrade, due to the fact that the inclination of the ecliptic would then be at its minimum, and further that since that date it has been growing slightly more severe.

In the first two chapters of my new book, "Ice or Water," I have given an elaborate analysis of the astronomical conditions affecting climate, and notably of changes affecting the inclination of the ecliptic, showing that the problem is a good deal more intricate than has been generally thought, and that it has to be qualified by many conditions. I do not, however, propose to raise any issue with Ekholm on the matter, and he is mathematically approximately right.

Brögger has, as we have seen, tried to equate the archæological evidence with the theory of Ekholm by giving a higher value to the length of time during which the second stage of the Neolithic age persisted than I have here tentatively given. I am not constrained

to question his argument and conclusions either, which, like mine, are merely tentative.

He goes on to argue further that, during the period since the *Litorina* sea was initiated, the climate of Scandinavia has become distinctly colder, if it has changed at all, and he even seems to adopt Ekholm's suggestion that it has become colder to the extent of reducing the midsummer temperature to the extent of 2 degrees C.

Whatever the quantitative value of the suggestion, the external and supplementary evidence seems to me to amply sustain the main contention of the Norwegian writers, and to show that for a long time past, whether it be for 6,000 or 8,000 years, and not impossibly the latter, the climate of Scandinavia has been growing colder and not growing warmer.

Let us shortly turn to this supplementary evidence. In the first place, then, it seems to me that the dominating climatic factor in terrestrial areas depends very largely upon their latitude, an element which is fixed, and their elevation above the sea-level, which is variable. The higher the land, especially in high latitudes, the lower, *cæteris paribus*, the mean temperature. This is an elementary axiom of meteorology. Inasmuch as the Scandinavian lands in the *Litorina* time were more submerged than, and not so high above the water in the Central and Northern Baltic as, they are now, it follows inevitably that the mean climate of the land, in so far as it was affected by its height above the sea-level, was warmer in the *Litorina* time than it is now.

Secondly, in northern latitudes salt water has a higher mean warmth than fresh water; the latter, again, freezes much more easily, and supplies, therefore, a great refrigerator in Winter, when the salter water is more open. Inasmuch as *the* feature of the *Litorina* time in the Baltic was the greater salinity of that sea, it follows that as the Baltic has been becoming less saline it has also become cooler, so that in both respects the tendency has been in the direction of a severer climate.

A third element, working in the same direction, is caused by the fact that the inflowing water from the North Sea is itself warmer as a whole than the outflowing water from the Baltic, and as the former was present in larger proportionate quantities in the *Litorina* time than now this again confirms the same conclusion.

Let us now turn to the fauna and flora of Scandinavia and see what it tells us. There cannot be a doubt that since the Baltic breach took place the fauna and flora of the Scandinavian peninsula and of the Baltic islands has not been in a position to receive fresh recruits and accessions from beyond the sea. The peopling of such isolated areas by the vagabonds of the biological world seems to me to be a quite fantastic idea, and the number of land plants and animals (other than regular or irregular migrants from the classes of birds and insects) which have reached the lands in question since the land-bridge was broken down must have been insignificant.

We may accept the present fauna and flora of Scandinavia and the Baltic islands, therefore, as a fair measure of what the climate of

those lands was when the Baltic bridge was broken. There may have been a partial extinction of forms due to various causes, but the climate of the land was at least tolerant of all the various living beings which now exist there and which must have reached there overland.

It is necessary to emphasize this because the position has been somewhat sophisticated by the efforts of the Northern botanists to press certain local conditions into a general law. That general law seems to me inapplicable, at all events, to the period which has elapsed since the *Litorina* stage of the Baltic history began. It has been often affirmed, for instance, on the authority of Steenstrup, that the bogs of Denmark afford a kind of thermometrical standard of change of climate, marked by the succession of the forests embedded in them. At the bottom of all are pine trunks. The pine has long ceased to grow in Denmark, and is not known traditionally there. Above the pines come oak-trees. The oak is also an infrequent tree in Denmark. The present forests of the country are composed of beeches, and it is argued that this is the general law of succession of these trees, the fact being that when we go to Norway we find that the oaks underlie the pines. Thus, as Professor James Geikie says, "Mr. Blytt has recorded that in South-Western and Southern Norway oaks and alders occur at the bottom of the bog, which is of variable thickness and formed of aquatic and marsh-loving plants. Above this under portion comes a second forest layer, composed chiefly of pines, which are, in their turn, buried under a second bed of sphagnum peat. Lindsberg and others tell us of exactly similar phenomena in the peat bogs of Scania. There, as in Norway, the bottom forest beds are formed of leafy trees, while the upper ones are chiefly coniferous" ("Prehistoric Europe," pp. 528–9). Professor Geikie has tried to get over this difficulty, but quite unavailingly (id., pp. 5, 35, 36). The fact is the succession of these trees was long ago shown to be, not a test of climate, but of another thing altogether. When the forest fires take place in the barren lands of America or in Siberia, it is found that a forest of leafy trees nearly always succeeds one of coniferous trees, and *vice versâ*, and the explanation is that each class of tree more or less exhausts the special products of the soil suited to it, and thus gives a chance to its rivals to supplant it. Again, the forests of beech which now grow so largely in Scania and Denmark do not grow over the remains of the buried pines and oaks; these lie in bogs whose surface sustains a growth of birches. The beech does not like such soil as bog earth, the deep clay in which the oak luxuriates or the sand wastes where the pine thrives, but loves chalky and marly soils and gravels.

I take it that the distribution of the trees in these areas was always rather dependent on the constituents of its subsoil and on whether it was for the time being drained or very wet than otherwise, and was always dominated by local circumstances. Thus the beech, instead of being quite a new-comer into the North, was there from early times, but did not thrive on bogs or in land where clay soil abounds, and therefore the remains of beech do not naturally occur in the

peat, while the oaks and pines succeeded each other on such ground irrespective of any special order, and rather in accordance with accident than law and controlled by local and sporadic conditions.

What we know of the distribution of the beech in these countries is significant. It has been treated by some as quite a late arrival. It is, on the contrary, an old tree there. Thus Blytt says of it: "Its discontinuous distribution in Norway shows that it is a long time since it wandered thither. Along the whole west coast it only grows wild at Samistrand, north of Bergen. It also has a scattered distribution east of Lindesväs. That it is truly wild with us is shown, among other things, from the large number of lichens peculiar to beech woods which are found in the beech woods of Norway" ("Ueber zwei Kalk-tuff bildungen in Judbrandsdalen": Engler Bot. Jahr. Beiblatt, p. 18, 1892).

This is remarkable testimony, since it shows that the beech is an old denizen of Norway, and we can hardly doubt that it was living there at the time of the Baltic breach, otherwise it must have been introduced by man, which is incredible, for it could not cross the Sound and the Belts, nor are its seeds adapted to aerial flights. It is also old in Denmark, for R. Sernander reminds us how, in 1873, Hansen described in a peat-bog, near the lake of Kjedle, a mass of leaves and a specimen of the fruit of the beech at a depth of 6 feet (Engler Bot. Jahr., xv, 85). Jensen also cites remains of the beech as occurring with those of the pine, oak, hazel, etc., in the marine beds of Randsbaek, in Vendyssel, in Jutland (see Denm. geol., unter., 1st raekke, iii, 308). This proves that even in Denmark the beech is a very old tree, and that local circumstances have combined to produce the particular succession in certain places as described by Steenstrup.

I therefore venture to question the feasibility of separating the most recent period of Scandinavian history into a succession of epochs marked by the prevalence of a particular tree. That may be possible at an earlier horizon, but not since the *Litorina* sea was initiated. The attempt means applying quite local conditions to illustrate widespread geographical problems.

There is, however, botanical evidence of another kind which points the same moral as the evidence already adduced, and is in favour of the trend of climatic change having during recent millennia been from a warmer to a colder stage.

There is evidence from the fjelds in Norway that the forests in the upper ground are shrinking and the trees in their upper stretches are dying, just as the same thing is happening in certain districts in the Alps. The nomenclature of the northern part of the country also affords evidence that since the human period there has been a corresponding shrinkage in the area where cereals can grow.

The botanical evidence from Scandinavia, therefore, fully sustains that deduced from the mollusca of the Cattegat by Petersen and others, in favour of the conclusion that the climate of the peninsula has been growing colder in the most recent geological times.

This is an important and ominous fact to be remembered by those who, looking across the horizon separating us from the penultimate changes in the world's history, see there a portentous ice age, swathing half the northern hemisphere in ice, which actually, in the eyes of some, crept up to the very threshold of our time. It is clear that the facts and conclusions here discussed, so far as they go, give no kind of support to such an hypothesis. They point unmistakably the other way, namely, to a recent deterioration instead of an amelioration of climate. We must go much further afield than the last 6,000 or 8,000 years if we are to find any substantial basis for that theory in Scandinavia, and *a fortiori* in lands, like Britain, situated in lower latitudes.

V.—Note on the Species of *Palæomastodon*.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

DETAILED examination of the remains of fossil mammals from the fluvio-marine beds (Upper Eocene) of the Fayûm has, in several cases, shown that the number of species of the various genera has been underestimated. This is especially the case with *Palæomastodon*, of which originally only one species, *P. beadnelli*, was recognised. Subsequently another form, *P. minus*, was named, and now it has become necessary to establish at least two other species, to one of which probably by far the greater number of the specimens collected must be referred.

The species of *Palæomastodon* fall into two sections, in one of which the posterior end of the symphysis of the mandible is situated considerably in front of the level of the anterior premolar, while in the other it is only very little in front of that point. The first group, moreover, is distinguished by the comparative simplicity of the molars, in which the accessory cusps are scarcely at all developed, and by the small size of the talon of the last lower molar; into this subdivision the original species, *P. beadnelli*, falls, together with a much smaller form for which the name *P. parvus* is now proposed. The type-specimen of this new species is the right ramus of the mandible, with the premolars and molars *in situ*, though somewhat crushed. The posterior border of the symphysis is about 5·5 centimetres in front of the anterior premolar, which at once distinguishes this form from the two species belonging to the other group. The third molar consists of two transverse ridges, each composed of two tubercles, and a smaller third crest consisting of a large outer and a small inner tubercle; there is no talon unless this third ridge is so regarded; there is a small intermediate tubercle in the anterior valley, but otherwise accessory cusps are wanting; the enamel is very smooth, and the cingulum is practically absent. M. 2 is trilophodont, but the last ridge is smaller than the others; it consists of an outer, larger and an inner, smaller cusp. The dimensions (in centimetres) of the molars in this specimen are:—

	Length.	Breadth.
m. 1	3·9	3 (app.)
m. 2	4·4	3·2
m. 3	4·5	3·2 (app.)

So far as its molar pattern is concerned, both this species and *P. beadnelli* seem to be more primitive than the other species referred to below, but on the other hand *P. beadnelli*, by its larger size, and both it and the present species in the elongation of the mandibular rami, appear to be more specialised. This intermingling of primitive and specialised characters is to be expected in a group represented by several contemporary species and undergoing rapid change in a given direction, the final product, in this case *Tetrabelodon* or some closely allied type, being the resultant of the various modifications, and here combining the great elongation of the mandible with increased complication of the teeth.

The second group, in which the posterior border of the mandibular symphysis is immediately in front of the anterior premolar and the molars are complicated by the addition of accessory cusps, also includes two species. Of these one, *P. minor*, has already been described (Geol. Mag. [5], Vol. I, p. 115); the other is a much larger form, and is important as being probably the commonest of all the species: for this the name *P. wintoni* is suggested, in honour of Mr. W. E. de Winton, by whom the expenses of my third collecting trip to the Fayûm were defrayed. It is considerably larger than *P. parvus* and *P. minor*, but smaller than *P. beadnelli*. From this last species it is also distinguished by (1) the extension back of the symphysis so that its posterior end is only just in front of the anterior premolar; (2) the position of the mental foramen on the side of the symphysis instead of behind it; (3) the greater complication of the molars and their greater length in proportion to their width; the last lower molar consists of three transverse crests and a distinct talon. The type-specimen is a mandible with the incisors and posterior molars *in situ*. The dimensions (in centimetres) of this specimen are:—

Length from condyle to tip of symphysis	74
Width of symphysis at narrowest	8
Length of symphysis	21

The dimensions of the teeth are:—

	Length.	Width.
m. 2	5·5	3·5
m. 3	7·4	4·4

Probably the greater number of the *Palæomastodon* remains so far collected belong to this species, but in the absence of associated series of bones it is not possible to be sure of this, although it appears that no mandibles of the type of *P. beadnelli* have been obtained in the pits from which most of the specimens have been collected.

The above-named species will be described more fully and figured in the forthcoming "Catalogue of the Tertiary Vertebrata of the Fayûm."

NOTICES OF MEMOIRS, ETC.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. SEVENTY-FIFTH ANNUAL MEETING, HELD IN SOUTH AFRICA AT CAPE TOWN AND JOHANNESBURG, AUGUST 15TH TO SEPTEMBER 1ST, 1905.

LIST OF PAPERS READ IN SECTION C, GEOLOGY.

Professor H. A. MIERS, M.A., D.Sc., F.R.S., F.G.S., President.

Read at Cape Town, August 16th to 18th.

A. W. Rogers.—Lecture on the Outlines of the Geology of Cape Colony.

Professor W. J. Sollas.—The Continent of Africa in relation to the Physical History of the Earth.

Professor R. Broom.—The Classification of the Karroo Beds of South Africa.

J. Lomas.—Report of the Committee on the Fauna and Flora of the Trias of the British Isles.

P. F. Kendall.—Report of the Committee on Erratic Blocks of the British Isles.

A. R. Dwerryhouse.—Report of the Committee on the Underground Waters of North-West Yorkshire.

Dr. Wheelton Hind.—Report of the Committee on Life-zones in the British Carboniferous Rocks.

H. C. Schunke-Holloway.—The Physical Geography of Cape Colony.

A. W. Rogers.—Glacial Periods in South Africa.

Professor A. Penck.—Changes of Climate as shown by Movements of the Snow-line and Upper Tree-Limit since Tertiary Times.

Professor W. M. Davis.—The Sculpture of Mountains by Glaciers.

R. N. Rudmose Brown.—The Scottish Antarctic Expedition's Visit to Diego Alvarez or Gough Island.

Professor A. Young.—On a Subterranean Tide in the Karroo.

A. L. du Toit.—The Stormberg Formation in Cape Colony.

J. Milne.—Recent Advances in Seismology.

H. T. Ferrar.—On the Geology of South Victoria Land.

E. H. L. Schwarz.—Baviaan's Kloof: a Contribution to the Study of Mountain Folds.

J. W. Stather.—Report of the Committee on the Fossiliferous Drift-Deposits at Kirmington, Lincolnshire.

Read at Johannesburg, August 29th to September 1st.

PRESIDENT'S ADDRESS. (See GEOL. MAG., pp. 417, 473, 519.)

Professor J. W. Gregory.—On the Rhodesian Banket.

Professor J. W. Gregory.—The Indicators of the Goldfield of Ballarat: a Study in the Distribution of Gold Pockets.

Professor R. Beck.—On the Relation between Ore Veins and Pegmatites.

Dr. A. P. Coleman.—Magmatic Segregation of Sulphide Ores.

Professor G. A. J. Cole.—Marginal Phenomena of Granite Domes.

H. S. Harger.—The Diamond Pipes and Fissures of South Africa.

F. P. Mennell.—Relation of the Igneous Rocks to the Crystalline Schists.

G. W. Lamplugh, F.R.S.—Report on the Batoka Gorge of the Zambesi, and the Surrounding Country between the Victoria Falls and the Confluence with the Deka River. (See p. 529.)

Professor A. Penck.—Glacial Deposits of the Alps.

H. Kynaston.—Recent Work of the Transvaal Geological Survey.

Dr. F. H. Hatch.—The Correlation between the Pre-Karroo Rocks of the Transvaal and those of Cape Colony.

Dr. F. H. Hatch.—On an Instrument for Surveying Boreholes.

W. Anderson.—On the occurrence of Fossiliferous Rocks of Tertiary Age in Natal and Zululand.

S. S. Dornan.—The Geology of Basutoland.

C. Baring-Horwood.—The Dolomite Formation of the Transvaal.

W. Anderson.—On the occurrence of Fossiliferous Rocks of Tertiary Age in Natal and Zululand.

E. T. Mellor.—Evidences in the Transvaal of Glacial Conditions in Permo-Carboniferous Times.

G. W. Lamplugh, F.R.S. — Note on the occurrence of Dwyka Conglomerate at Kimberley Mine.

H. S. Harger.—The Diamond Pipes and Fissures of South Africa.

Dr. J. T. Carrick.—Geology of the West Rand.

F. P. Mennell.—Relation of the Igneous Rocks to the Crystalline Schists.

E. Heneage.—A Consideration of the Archæan Period of North America and South Africa, with reference to Mineral Occurrences.

Photographs of Russian fossil reptiles, lent by Professor Amalitzky, of Warsaw, were on exhibition in the Committee-room of Section C.

The following is a list of the titles of papers bearing upon Geology which were read in other Sections of the British Association in South Africa :—

Section A.—Mathematical and Physical Science (Aug. 30th).

Professor J. Milne, F.R.S.—Report of the Seismological Committee.

Professor J. Milne, F.R.S.—Recent Advance in Seismology.

Section B.—Chemistry.

Professor P. Hahn.—A South African Mineral Spring.

Section D.—Biology (Zoology).

Report of the Committee on the *Index Animalium.*

Professor R. Broom.—On the Origin of Mammals.

Professor W. B. Scott.—Convergent Evolution as illustrated by the Litopterna—a group of fossil Ungulata in Patagonia.

Section D.—Biology (Botany).

A. C. Seward, F.R.S.—The Fossil Floras of South Africa.

Section H.—Anthropology.

Report of Committee on Lake-Village of Glastonbury, Somerset.

J. P. Johnson.—Stone Implements in South Africa.

REVIEWS.

I.—Geological Survey of England and Wales.

The Geology of the Country South and East of Devizes. By A. J. Jukes-Browne, B.A., F.G.S. pp. 61. (1905. Price 1*s.*)

IN this memoir, which is accompanied by a geological map (Sheet 282, price 1*s.* 6*d.*), very clearly printed in colours, we have a description of a large part of Salisbury Plain, including the War Department land between Tidworth and Bulford, and also of the Vale of Pewsey as far east as Burbage. The general structure of the area is shown in a line of coloured section, engraved at the foot of the map, and by a column of strata, drawn to scale. Beds from the Oxford Clay to the Reading Beds and alluvial deposits are depicted on the map and described in the memoir. There are, however, some missing strata; the Corallian beds, for instance, do not appear at the surface, as they are cut out by a fault; and there are striking evidences of unconformable overlap or overstep where the Lower Greensand crosses the outcrop of the Portland Beds, and where the Gault and higher Cretaceous rocks extend over the Lower Greensand on to the Jurassic strata. The remnants of Reading Beds rest unconformably on the Upper Chalk. The district is one that was described in part by the old masters, Lonsdale and Fitton, while the country around Devizes is especially associated with the name of William Cunnington, who amassed a rich collection of fossils, many of them now in the British Museum and others in the Devizes Museum.

Full particulars are given of the strata and their fossils; the account of the Cretaceous rocks, which occupy most of the area, extending over five of the eleven chapters. There are notes also on the economic deposits, including the Seend iron-ore, which is no longer worked, and on the springs and water-supply.

With the exception of the valley deposits there is very little 'Drift,' the few tracts of clay-with-flints being remarkable over the wide expanse of the Chalk downs. Mr. Jukes-Browne expresses his opinion "that this deposit has been formed almost entirely from Eocene material, and that it only occurs at places where the present surface is not far below the ancient plane of erosion on which the lowest Eocene deposits were laid down."

II.—Geological Survey of Canada.

By Robert Bell, I.S.O., M.D., D.Sc., LL.D., F.R.S. Summary Report for the Calendar Year 1904. 8vo; pp. 392 and xxxviii, figures and maps. (Ottawa: S. E. Dawson, 1905.)

THIS report deals in a general way with the operations of the Geological Survey Department for the year ended 31st December, 1904. The first part (pp. i–xxxviii) contains a brief résumé of the work carried on during that year at headquarters,

consisting of the preparation of the numerous publications issued by the department, the making of the maps, matters relating to economic geology, the care of the collections, etc. The field-work ("officers' reports") fills up the rest of the volume.

Mr. R. G. McConnell describes his exploration of the new goldfield of the Kluane district, Yukon. This embraces Alsek River, Kluane Lake, and the north-eastern slope of the St. Elias range. The last has become familiar to geographers through the Italian expedition of 1897 under the Duke of the Abruzzi, when an ascent of Mount St. Elias (the highest point in Alaska) was made. A great variety of massive igneous rocks occur in this range. Unlike the Rocky Mountain range, there is no evidence of overthrust faulting, reversing the normal sequence of the beds, though they are highly tilted. The gold is of local origin, and is derived from the quartz veins cutting the Kluane schists. The production is at present small, but worked by more economical methods there seems promise of future success.

Mr. Joseph Keele examined the Duncan Creek mining district, Stewart River, Yukon territory, where also 'coarse' gold, derived chiefly from the bed-rock (quartz and mica-schist), is widely distributed. Maps accompany both these reports.

Dr. R. W. Ells and Mr. R. A. A. Johnston were occupied in working out the geological structure of the Nicola Coal-basin, British Columbia, with special reference to the occurrences of coal and the ores of iron and copper. The rocks of this area were described in 1877–8 and in 1894 by Dr. G. M. Dawson, who gave the name "Nicola Series" to the volcanic rocks (Triassic) and "Coldwater Group" to the sedimentary (Tertiary) rocks. The former consist of diabase, porphyrite, rhyolite, andesite, felsite, and agglomerate, with which, locally, large masses of granite of later date are associated. The sedimentary rocks comprise conglomerate, sandstone, and grit, shale and beds of coal, which are in some places lignite of fair quality, as at Similkameen, but in other places they pass into bituminous coal, as in the Nicola Valley, where they form deposits of great value. A map, coloured geologically and on a scale of one inch to one mile, is appended to this report.

Professor R. W. Brock continued his work in the Lardeau mining district, British Columbia, begun in the previous season (1903). He describes the physical geography, glacial geology, solid rocks, and mining geology of the district. The value of the mining seems to be rather prospective than present. The ores found are gold, silver, and lead.

Dr. R. A. Daly contributes a report on the geology of the western Cordillera, along the line of the international boundary (49th parallel).

A few pages are occupied by Professor John Macoun, the well-known botanist to the Survey, in a report upon the natural history of the "National Park" (Rocky Mountain Park), including also its botany.

Mr. D. B. Dowling continued his examination of the coalfields of the Rocky Mountain region adjacent to the line of the Canadian Pacific Railway, where he has made important discoveries of coal-seams. This report is accompanied by a coloured geological map of the Costigan Coalfield, Alberta, and other illustrations.

During the Canadian Government expedition to "Hudson Bay and Northward" under Mr. A. P. Low, some observations were made as time would allow (the object of the expedition being other than scientific) upon the geology and natural history of the coast and adjacent regions. The scientific results of this expedition indicate the importance of the presence of trained scientific men on such expeditions, if full advantage of them is to be taken. The western coast of Hudson Bay was geologically examined from the head of Chesterfield Inlet to that of Wager, and track surveys made. The western shore of Southampton Island and Ungava Bay were similarly examined, a survey of 2,041 miles being in all accomplished. The predominant rocks observed on Southampton Island were a coarse granite-gneiss with broken bands of diabase and chloritic schists. These rocks are overlain by Silurian limestone in places. On the eastern shore of Ungava Bay the rocks are all Archæan, principally granite-gneiss, with a large amount of basic irruptives, such as gabbro and anorthosite. Large collections of rocks, fossils, the northern mammals and birds, as well as fishes and marine invertebrates, were made, as also Arctic plants. The expedition occupied 14 months from the time of leaving Halifax to its return to that port.

Mr. Charles Camsell made geological and the necessary topographical surveys in Eastern Manitoba and those parts of the country between Lake Winnipeg and the Severn River. This area is occupied by rocks of Archæan age, principally granites and gneisses. Mr. Camsell traced the boundaries of the eastern extension of the Huronian area around Red Lake, and also discovered some additional small areas of Huronian rocks.

Mr. Wm. McInnes followed up his interesting explorations of the previous year in the extensive and hitherto almost unknown region of the Winisk River and surrounding country, lying to the south of Hudson Bay proper. His work adds materially to a knowledge of the rock-formations of this region.

Mr. W. J. Wilson worked in the country lying northward of Long Lake, north of the central part of Lake Superior, including the head-waters of some large branches of the Albany River. He traced out a further extension of a known area of Huronian rocks in which gold, copper, and iron ores may eventually be found.

Mr. Owen O'Sullivan surveyed and explored the southern and western coasts of James Bay as far north as Cape Henrietta Maria. These coasts, occupying the central part of the map of Canada, had not previously been very accurately delineated. The work was undertaken to supply this want, and at the same time to observe and record the geological features of this region. A map of the coastline surveyed is added to the report.

Messrs. E. D. Ingall and Theo. Denis continued the detailed geology of the typical Huronian area in the Bruce Mines district of Algoma. A map illustrating the geology of this area accompanies the report, which, in addition to the geological interest attached to it, is expected to be of service in the future search for copper deposits.

Dr. A. E. Barlow has an interesting report on Corundum in Ontario. The occurrences of this valuable mineral in Canada are confined to a series of eruptive rocks frequently presenting a well-marked foliation, in close accordance, as a general rule, with that of the surrounding granites and diorites (Laurentian gneisses). The corundum-bearing rocks are of syenitic or gabbroic type. "The simplicity and, at the same time, completeness of the Canadian occurrences of corundum, combined with the fresh and unaltered character of the associated minerals, at once removed all doubt as to the pyrogenetic origin of this mineral, showing clearly its development as a primary constituent from a highly aluminous silicate magma, as one of the first products of its crystallization." It is worthy of note that Canada is now the largest producer of corundum in the world.

Dr. Barlow, associated with Dr. G. A. Young, continued work in the Temagami Lake region.

Professor W. A. Parks investigated a part of the country on the western side of Lake Timiskaming and thence northward to some of the branches of the Blanche River in connection with the recent discoveries of silver and cobalt in that district. He mapped out the rock-formations of the region, and indicated the zone in which the two metals occur.

Mr. A. F. Hunter was occupied in the district from Orangeville northward to Thornbury, Ontario, in tracing the interesting high-level shore-lines along the flanks of the Blue Mountain escarpment south of Georgian Bay (Lake Huron).

An important task was begun by Professor Ernest Haycock in working out the detailed geology of the upper Laurentian series in the south-western part of the county of Ottawa. This area contains a great variety of crystalline rocks, which Professor Haycock divides into nine groups, consisting of gneiss, crystalline limestone, quartzite, altered greenstone, etc. After further work it is intended to issue a map of the district on a scale of one inch to one mile, to show the geological structure and the distribution of the rocks in a manner similar to that done by Sir William Logan on his map of a typical area of upper Laurentian rocks in the county of Argenteuil.

The geology of part of the county of Ottawa engaged the attention of Mr. J. F. E. Johnston and proved to be of a very intricate nature. The Lièvre River and Templeton phosphate district are included in the area examined.

Dr. Robert Chalmers investigated the surface geology of the Gaspé peninsula and of the country along the south side of the lower St. Lawrence from Gaspé south-westwards towards the city of Quebec. Thence he worked northward to Lake St. John and the valley of the Saguenay, noting that there are a number of

interesting problems relating to glaciation, geomorphic changes, altered drainage-lines, etc., offering themselves for investigation and study in this region.

Dr. J. A. Dresser continued the work of previous years by examining and defining the copper-bearing rocks of the Eastern Townships (Sherbrooke district), thus enabling prospectors to confine their labours to the productive zones only. The investigation applied mainly to the pre-Cambrian rocks, and it was found that the workable copper is chiefly restricted to certain igneous portions of these rocks. A petrographic subdivision of the pre-Cambrian strata into volcanic (copper-bearing) and sedimentary rocks was made in conformity with this discovery.

The completion of the study of the geology of certain parts of Charlotte County, New Brunswick, was undertaken by Dr. R. W. Ells. This work included the examination of the rocks of Grand Manan Island, and of portions of the shore of the Bay of Fundy, between Beaver Harbour and Point Lepreau, where, at different places, through the agency of intrusives, the ordinary sedimentary rocks of Silurian and Devonian age became altered to the condition of schists of pre-Cambrian aspect.

Professor L. W. Bailey was occupied in making geological investigations in New Brunswick (1) in the search for fossils in the pre-Carboniferous rocks of York and Carleton Counties, and (2) in obtaining information relating to the economic minerals of New Brunswick. The study of the fossils collected was intrusted to Dr. H. M. Ami, whose description of them forms an appendix to the report. Several species of graptolites from the black carbonaceous shales on the Tête à Gauche River, near Bathurst, Gloucester County, New Brunswick, were named, their facies suggesting an Ordovician fauna belonging to one of those zones of graptolites occurring on the St. Lawrence and Hudson Rivers. Some Brachiopods from the S.W. Miramichi River were too obscure for specific identity. Tracks of some organism, probably an annelid or other related form, were found at Tapley's Mill, Woodstock, New Brunswick, in an indurated slate; to this Dr. Ami gives a new generic and specific name—*Eugyrichnites minutus*. The geological origin of the slates is not determinable from the evidence at hand, but the new designation of the fossil is offered for the sake of reference.

Mr. Hugh Fletcher, with two assistants, continued field-work in Nova Scotia in the counties of Cumberland, Hants, King's, and Annapolis, including practical researches in the coalfields and iron-ore districts of those counties. A notable discovery was made by Mr. Fletcher, by whose advice a borehole was sunk to the depth of 2,340 feet, in the shape of a ten-foot seam of coal. This important piece of work opens at once a prospect of finding numerous workable coal-seams throughout a new area fifty miles in length by thirty in breadth.

A preliminary geological map of the Nictaux and Torbrook iron district of Annapolis County illustrates this report.

Mr. E. R. Faribault was engaged upon a special report on the

goldfields of Eastern Nova Scotia; a general map of the gold-bearing rocks of the province from Canso to Yarmouth, and the granite areas, and a geological and structural map of the gold-bearing rocks of the eastern part of the province, from Isaac Harbour to Mount Uniacke. He is also preparing a bulletin on the occurrence of gold in Nova Scotia generally.

An interesting account by Mr. R. A. A. Johnston of a meteorite which fell August, 1904, near the village of Shelburne, Ontario, concludes the geological section of this report. The fragment, irregular and angular in form, weighed 12½ lbs., and was marked by the pittings and corrugations characteristic of many meteoric bodies. Another specimen which may or may not have formed part of the first was found not far from it, and was examined superficially by Mr. Johnston. This last weighed 28 lbs., and was found at a depth of about 2 feet from the surface of the ground, into which it had sunk in its fall. It is intended by its present owner to be sent to the University of Helsingfors, Finland. It would seem a matter for regret that this interesting specimen was not secured for the Museum at Ottawa.

Dr. G. C. Hoffmann gives a succinct account of the work done in the departments of Chemistry and Mineralogy. This was almost exclusively confined to the examination and analysis of such ores and minerals, etc., as were considered likely to prove of economic value. Following this is a summary by Mr. C. O. Senécal of the cartographical work accomplished under his supervision as geographer and chief draughtsman.

Dr. J. F. Whiteaves reports upon the work of the department of Palæontology and Zoology, and promises a fourth part of the "Palæozoic Fossils," to consist of the fossils of the Silurian rocks of Keewatin, Manitoba, and Saskatchewan contained in the museum. Mr. L. M. Lambe's work in vertebrate palæontology is also referred to.

A summary by Mr. E. D. Ingall and his staff of the mineral production of Canada in 1904 shows an aggregate value of over £12,000,000. The report concludes with four appendices consisting of (i) assays of ores referred to in Mr. Ingall's report; (ii) notes by Dr. Ami on some obscure fossils collected by Mr. Hugh Fletcher in Nova Scotia; (iii) description by Dr. Ami of a new species of *Bythotrephis* (*B. Yukonensis*) from the Yukon District; and (iv) determinations by Dr. Ami of fossil plants from British Columbia and the North-West Territories collected by Professor Penhallow of McGill University, Montreal.

This voluminous report, though only a summary of the work accomplished by the very efficient staff now carrying on the Survey, contains a vast amount of information relating to the physical resources of the Dominion, and indicates especially the great development that is taking place in mining in all its branches. A feature which greatly enhances the usefulness of the report is the number of maps that accompany it. We must also compliment the writers on the clearness as well as succinctness of their summaries.

ARTHUR H. FOORD.

REPORTS AND PROCEEDINGS.

Geological Society of London.

The opening meeting of the Session was held at Burlington House on the evening of November 8th, 1905. J. E. Marr, Sc.D., F.R.S., President, in the chair.

The President announced that the Council at their meeting on June 28th last had passed the following resolutions :—

1. "The Council desire to record on their Minutes an expression of their deep regret at the death of their distinguished Treasurer, and of their grateful recognition of the loyal and effective services which for so long a series of years he has given to the Geological Society as Secretary, President, Treasurer, and Member of Council."

2. "That a copy of this resolution be forwarded to Mrs. Blanford, with an expression of the deep sympathy of the Council with herself and family."

The following communications were read :—

1. "The Coast-Ledges in the South-West of the Cape Colony." By Professor Ernest Hubert Lewis Schwarz, A.R.C.S., F.G.S.

The following coast-shelves have been recognized by the author in Cape Colony :—

NAME OF SHELF.	WESTERN.	MIDLANDS.	EASTERN.	NATIVE TERRITORIES.
	ft.	ft.	ft.	ft.
Cyphergat.....	5000–6000?	5000–6000?	5450?	—
Sterkstroom.....	3500–4000?	4000?	4406?	4500?
Kentani.....	.....	.....	2500	2500
De Vlugt.....	1500	1000	1500	1500
Uplands	700	463	467	600
Bamboes Bay....	50–100	200	151	50–200
Sea-level	—	—	—	—
Agulhas	—600			

The most striking of these is the Upland shelf, which extends from Caledon to Port Elizabeth. It is cut by deep gorges into narrow ridges or 'ruggens,' but at a height the level tops of these ridges can be observed. The surface is in places covered with superficial deposits, cemented boulder-deposits, gravels, and sandy clays, hardened at the surface into ironstone or fresh-water quartzite. The author considers that this shelf cannot have been formed as a peneplain, but by marine denudation. On the 150–200 foot plateau there are deposits with marine shells, and in a depression on its top the evaporation of rain-water produces a large quantity of salt. The rock-shelf under the Cape Flats appears also to have been cut by the sea. The Agulhas Bank seems to consist of a succession of ledges, but it is not known whether further shelves extend beyond its margin. Taking the ledges together, the continent would appear to have been subject to lifts of 600 or 700 feet, with intermediate halts and set-backs. The author introduces the term 'absolute base-level of erosion' "to express the ocean-floor, including the shelf or level of erosion cut by the surf and off-shore currents that came near the water's edge when the depression of the present land-masses commenced." The author compares the shelves of Cape Colony with those described on the European and American sides of the North Atlantic, and he places the 'absolute base-level of erosion'

at 12,000 feet in North America, 8,000 feet in Europe, and 1,200 feet in South Africa. With these varying heights he correlates the topography of the bordering continents—the sharp divides, open river-valleys, permanent rivers and deltas, of Europe and America, where the movement has been downward and has almost reached bottom, in contrast with the flat undenuded divides, the steep, narrow gorges, the waterfalls, and the rocky river-gates of South Africa, which is on the up-grade and probably near the top.

2. "The Glacial Period in Aberdeenshire and the Southern Border of the Moray Firth." By Thomas F. Jamieson, F.G.S.

One of the most interesting features in the Glacial geology of Aberdeenshire is the Red Clay found along the eastern coast of the county. It consists of red sediment brought by ice flowing along the coast from south to north, which also carries rocks from the coast between Montrose and Lunan Bay. The clay is sometimes finely laminated; at other times it is mixed with stones; and at times, again, contains esker-like mounds of gravel. It includes fragments of Crag-shells and of Mesozoic limestone. The purer masses of clay seem to have formed in a sheet of water lying in front of the ice, between it and the land, during the retreat of the Aberdeenshire ice, and at a time when the coast was submerged beneath water to a level exceeding 300 feet above the present coastline. Evidence of the northward motion of the ice is given from striæ, the transport and removal of flints, and the bending over of the edges of folia of gneiss. The red clay is underlain by a grey clay, and sometimes covered by a similar one. The author has recently discovered remains of a still older, dark indigo in colour, and containing small fragments of sea-shells. This has, however, been swept away in most places by subsequent ice-movement. In Banffshire a fine dark clay seems to have been formed under the same circumstances as the Red Clay of Aberdeenshire. The only evidence of warm intervals in this part of Scotland is that inferred from the melting away of the masses of ice, which preceded and followed the deposition of the Red Clay and the shell-beds of Clava.

On the southern border of the Moray Firth the author gives examples of glacial marking on the rocks, and refers to the transport of boulders, including a huge mass of Oolitic rocks 40 feet thick, a mass of clay once considered to be an outlier of Lias, 'pipe-rock,' and the fossiliferous Greensand débris at Moreseat, now considered to have been transported by ice. The ice appears to have been 4,000 to 5,000 feet thick about Inverness, in order to reach to and overflow Mormond in North-Eastern Aberdeenshire. The terraces of gravel found at decreasing heights on the Spey, near Rothes, seem to have been formed during stops in the retreat of the ice. Arctic shells of deep-water type, found in silt-beds south of Rattray Head, give evidence of a period of considerable submergence; but the recurrence of an ice-sheet appears to have destroyed most of this evidence, as is seen in a section at King Edward.

CORRESPONDENCE.

GEOLOGY OF DERBY, BURTON-ON-TRENT, ETC.

SIR,—Reading your review on the memoir of the Geological Survey, "The Geology of the Country between Derby, Burton-on-Trent, Ashby-de-la-Zouch, and Loughborough" (GEOL. MAG., September, p. 416), I notice that your reviewer has misread a very ambiguous statement, but I am surprised that he did not take exception to his own reading. The memoir states under the heading of Limestone Shales (which, by the way, in other publications members of the Survey have been calling Pendleside Series): "Both the limestone and shales are thinning out in this neighbourhood, and from attaining a thickness of 5,000 feet in Derbyshire are not more than 500 feet at Breedon"; with a footnote which says that even "this thickness is calculated on the supposition that there is not much Limestone hidden by the Trias." The Limestone Shales are stated to be 30 to 40 feet thick at Ticknall. Your reviewer, owing to the lack of capitals and general ambiguity, says the shales have thinned out from 5,000 feet in Derbyshire to some 500 feet at Breedon, when evidently the memoir means the whole Carboniferous Limestone and Pendleside Series. My chief object is to protest against the figures quoted for Derbyshire by the author of the memoir. I very gravely doubt that there are 3,000 feet of Limestone, and there certainly are not more than 800 to 1,000 feet of shales present in any continuous or unfaulted section.

Referring to the last paragraph on p. 75 of the second edition of the Survey memoir on North Derbyshire, which is quoted by Mr. Wedd on p. 9 of the Summary of Progress, 1904, I find the following:—"In the Mole-trap Mine 300 feet of shale were passed through before reaching the Limestone. The top of the shaft may be some 100 feet below the base of the Shale Grit, so that the Yoredale group will be here about 400 feet thick." This locality is near Cromford. Why the discrepancies between different publications of the Survey?

WHEELTON HIND.

A REMARKABLE BONE FROM THE SUFFOLK CRAG.

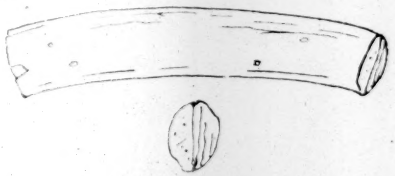
SIR,—Will you permit me to ask whether any of your readers can tell what has become of the specimen of which I give a rough outline? I first saw it in 1865 in the extensive Crag collection of Mr. Whincopp at Woodbridge in Suffolk. It afterwards passed into the hands of Sir Joseph Prestwich, at whose house I again saw it in 1889, and then took the measurements from which my sketch is drawn.

I believe it used to be an adage of the Survey that "a note made at the time is worth a cartload of recollection." This was it:—"Dec. 21, 1865, at Mr. Whincopp's. The collection is large and unique. One of the most remarkable things is what he calls a 'bludgeon.' It is a piece of a fossil rib bone, and appears to have been mineralised in the Crag. It has been partially sawn across at both ends. The ends show incrustations of stalagmite, but stained ferruginous. The fractures look like those of recent bone, as if it had been broken off before it was mineralised."

At a subsequent visit, February 9th, 1866, I noted: "The fracture

at one end is as much polished as the bone itself is, like all bones from the Crag; but at the other end decidedly less so. It was said to have been found with an urn."

Mr. Whincopp told me that the thing was brought to him by a carrier from the country, and seemed to have no definite information about it; but it was evidently a bone from the Red Crag, which was at the time largely worked for phosphatic nodules. The note which I made at Prestwich's house was this: "5th August, 1889. This specimen is now in the collection of Prof. Prestwich, where I saw it at this date. It weighs 2 lb. 7 ozs. The above is a fair representation of it" (now copied). The little pits on the surface are shallow excavations. Its length is 10½ inches and diameter 2 inches.



Scale, two inches to a foot.

Of course, the antecedent probability is against finding a specimen bearing signs of man's handiwork at such an early period as that of the Crag. But at every new stage to which his existence is pushed back there must always be a first find to break the record. The marine character of the Crag is not a serious objection, for, seeing that Mr. Whincopp's collection was remarkable for the large number of remains of land animals that it contained, there is no reason why, if man should have lived among them, one of his implements might not have been found along with their bones.

It is in the hope that this curious object may be brought to light, and examined by competent judges, that I venture to ask you to print this letter. O. Fisher.

Harlton, Cambridge, *October 1st*, 1905.

P.S.—Since writing the above I have met with the following memorandum, which I had overlooked: "Feb. 9, 1866. Mr. Whincopp's collection. The 'bludgeon,' which I particularly noticed when last here in December, is evidently formed from a fossil bone, a rib, but I think was a fossil before being made into a bludgeon."

The conclusion would be that it was cut off at one end before being mineralised, but that it was subsequently shortened to suit the requirement of some Neolithic man who had found it.

OBITUARY.

CAPT. FREDERICK WOLLASTON HUTTON, F.R.S., F.G.S.

Born November 16, 1836. Died October 27, 1905.

We regret to record the death of Capt. F. W. Hutton, F.R.S., Curator of the Canterbury Museum, Christchurch, New Zealand, on Friday, 27th October, at the age of 68, on board the R.M. s.s. "Rimutka," while on his return voyage from England to New Zealand, after a brief Summer visit to the old country.

F. W. Hutton was the second son of the Rev. H. F. Hutton, and was born at Gate Burton, Lincolnshire, 16th November, 1836. He was educated at the Southwell Grammar School, and later entered the Naval Academy at Gosport. Being over age when nominated for the Royal Navy, he served as a midshipman in the India Mercantile Marine. He joined the 23rd Royal Welsh Fusiliers in 1855, serving in the Crimea 1855–6; was in the relief of Lucknow under Lord Clyde; and took part in the capture of Lucknow, receiving the medal with two clasps. He entered the Staff College in 1860, passing out sixth on the list. Whilst stationed at Malta, in 1866, he communicated an excellent paper to the GEOLOGICAL MAGAZINE on the Geology of Malta (see Vol. III, pp. 145–152, and Pls. VIII and IX). More than twenty other papers are recorded to his credit in this journal, and eight in the Quarterly Journal of the Geol. Soc. Lond. In 1866 Capt. Hutton retired from the Army, and emigrated to New Zealand. At first he was attached as an Assistant Geologist to the Geological Survey of New Zealand in 1871; later on (1873) he was appointed Curator of the Otago Museum, and in 1877 Professor of Natural Science in the Otago University. In 1880 he was appointed Professor of Biology in the University of New Zealand, a post he held until 1893. He joined the Geological Society in 1861, was elected a Corresponding Memb. Zool. Soc. Lond. in 1872, and an F.R.S. in 1892. He was chosen President of the Australian Association for the Advancement of Science, 1901–2. He held for some years the post of Curator of the Canterbury Museum and Lecturer in Geology in Canterbury College, N.Z. He published a class-book of Elementary Zoology, 1879, and a large number of papers in the Transactions of the New Zealand Institute and other Scientific Societies at home and in the Colonies. He was an entomologist as well as a geologist: indeed, Capt. Hutton may be said to have been a good all-round naturalist and a very able scientific man.

Capt. Hutton married in 1863 the daughter of W. Montgomerie, M.D.

MISCELLANEOUS.

DIPLODOCUS CARNEGIEI. (Plate XXV.)

This huge Dinosaur (Pl. XXV) is one of the largest of ancient terrestrial animals, being 14 feet high and 80 feet in length. The head is very small, but the neck is extremely long and flexible. The teeth are confined to the front of the jaws, and are small and peg-like, and could only have served to collect the succulent vegetation on which the creature is supposed to have subsisted. The body is relatively short, but the length of the ribs and the massiveness of the limbs show it to have been of immense size and weight. The tail was of extraordinary length, and consisted of more than 70 vertebræ, being about half the total length of the animal. As the nostrils open quite on the top of the head, a position which would be particularly convenient to an air-breathing animal that lived under water, it has been suggested that it was probably semi-aquatic in its habits, living mostly at the bottom of shallow lakes and rivers, browsing on water-plants, and putting up its head to breathe.

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